② Zero May / May not be

102 → ③

10202 → ⑤

③ Not significant provided the significant part is Zero.

0.0124 → ③

0.0012 → ②

④ Zero B/w Non-zero digits is significant.

1.0012 → ⑤

⑤ Zero's to the right side : May / May not be Zero.

2000 → Non-significant

2000. → Significant.

then depends upon least Count.

∴ put least Count at the end.

2000
   1 → ④

least Count 10

2000
  10 → ③

least Count 0.1

2000.0
    .1 → ⑤

least Count 0.01

2000.00
    .01 → ⑥

By Assad Bajwa-

→ No Measurement is Absolute precise.
→ There is Uncertainty in Measurements Known As Error.

Errors-

Systematic

lab, person, device

↓

Zero Error

→ Correction factor can be applied.
→ positive / Negative and constant with the instrument.

Random

person, device, change in Environment.

→ Causes are UnKnown.
→ Correction factor Can't be applied-

Rules for final Calculations-

① For Addition (1) and subtraction (2):
→ add absolute Uncertainties / least Count.

② For Multiplication and division
→ add %age Uncertainties-

③ For power factor, Multiply power factor with its %age Uncertainty.
↳ 2/3
2 × 6% / 3 × 9% etc.

④ In case of timing experiments, Uncertainty in "T" is obtained by dividing least Count with # of Vibrations.

= 1s/20 → Uncertainty / Error

More Vibrations → Less Error.

→ Absolute = least Count

→ Fractional Uncertainty = least Count / Absolute
Measured Value

→ %age = fractional x100.

∴ For instruments, precision and accuracy is almost same But not for Measurements.

⑤ → More accurate Value → less precise.

Information Based

① One Year = 3.2×10^7 seconds = 3.2×10^{16} ns

② One day = 8.6×10^4 seconds.

③ Mass of Earth = 10^{25} Kg → Magnitude.

→ Light Year → For distance = 9.5×10^{15} m

Moon to Earth = 1 min 20s.

→ Sun to Earth = 8 min 20s (Basic).

pluto to Earth = 5h 20s.

→ Velocity → $\sqrt{E/\rho}$ has Unit → ms^{-1}

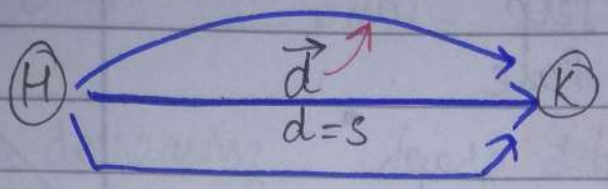
→ Intensity = $Kg\,s^{-3}$

Energy density = $Kgm^{-1}s^{-2}$ = Energy/Vol.

By Assad Bajwa.

Unit # 02 Motion And Force.

Displacement: Shortest directed distance.



Measured in Meter, [L], Vector, positive / Negative / Zero.

Displacement can't be greater than distance.

$\vec{d} < S$, $\vec{d} = S$ → $\vec{d} \leq S$

Revolution	Displacement	Distance
1/4	$\sqrt{2}R$	$2\pi R/4 = \pi R/2$
1/2	$2R$	$2\pi R/2 = \pi R$
1	Zero	$2\pi R$

position Vector

total distance in one revolution.

Rate of change of displacement → Velocity
→ Vector, +ve, -ve, Zero

Rate of change of distance → speed
→ Scalar, +ve

→ Equal displacement in equal Interval. Magnitude and direction same.

$V_{av} = \frac{\text{Total displacement}}{\text{Total time}} = 40/4 = 10 ms^{-1}$

Uniform / constant → same thing

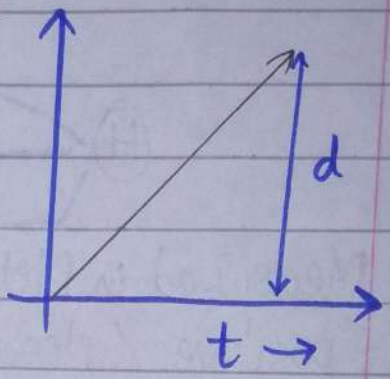
$V_{ins} = V_{ave}$

→ Body Moving with uniform "u" (→ constant), average is equal to instantaneous Velocity.

∴ Uniform Velocity → Position Vector changes.

$$V_{ave} = \frac{d}{t} = \frac{Perp}{Base} = \tan\theta$$

Slope of d-t graph.



θ ↑, tan θ ↑

Slope ↑, v More and More.

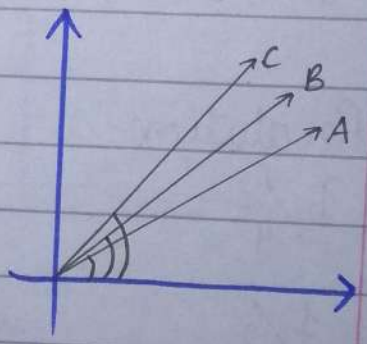
"Explanation"

① $\theta_1 = 29°$

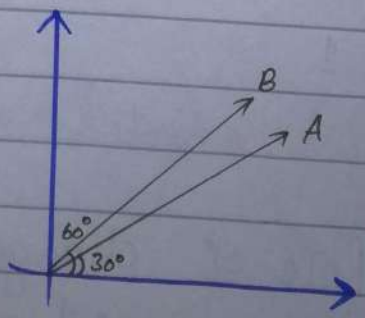
② $\theta_2 = 33°$

③ $\theta_3 = 65°$

C = Max Velocity.



D-t graph for A and B is shown in figure, ratio of v_B/v_A is



$$v_B/v_A = \frac{\tan 60°}{\tan 30°} = \frac{\sqrt{3}}{1/\sqrt{3}} = 3/1$$

∴ $\frac{\tan 60°}{\tan 30°} = \frac{3}{1}$

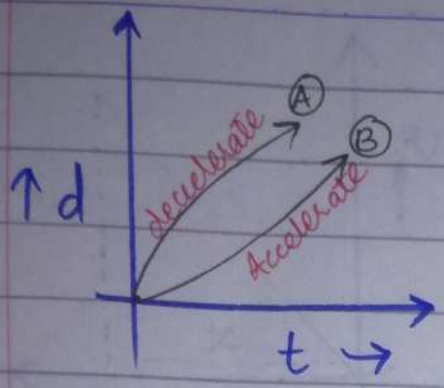
v_B is 3 times v of A.

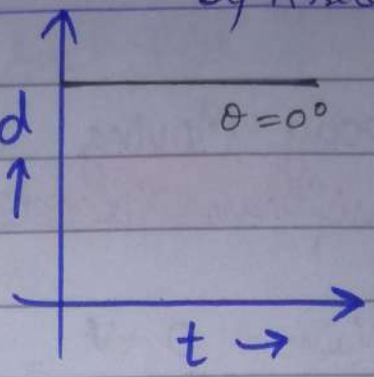
$V_B = 3V_A$

∴ $\frac{\tan 30°}{\tan 45°} = \frac{1}{\sqrt{3}}$

① $\tan 60° = \sqrt{3}$ ② $\tan 45° = 1$ ③ $\tan 30° = 1/\sqrt{3}$

By Assad Bajwa.





$v = 0$

Object at Rest.

Ⓐ → slope is decreasing

v = decrease

↳ Decceleration

Ⓑ → slope is increasing, v = increases ↳ Accelerate.

Velocity-Time Graphs:

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

Equal interval = Equal change of Velocity.

↳ Uniform Acceleration / constant Acceleration.

$$a_{ave} = \frac{\text{Total change}}{\text{Total time}} = \frac{15-0}{3-0} = 5\ ms^{-2}$$

→ 2nd

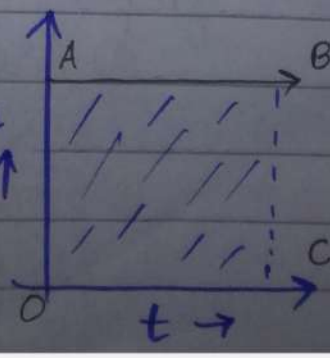
Body Moving With Uniform Acceleration,

$$a_{ave} = a_{ins}$$

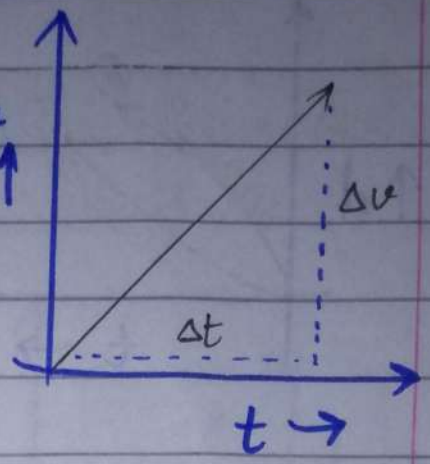
Constant velocity

Area of Reatangle = Distance

$$S = v \times t$$



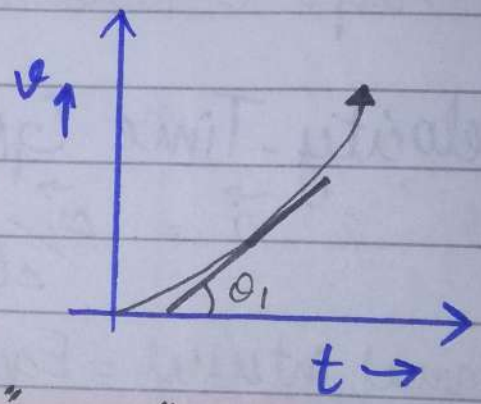
→ Body Moving with uniform acceleration



$V_{ave} = \frac{0+v}{2} = v/2$

$d = 1/2\ vt \ / \ 1/2\ at^2$ → Area Under the graph.

$a_{ave} = \frac{\Delta V}{\Delta t} = \frac{Perp}{Base} = \tan\theta =$ Slope.



→ Body Moving with ① Non-uniform ② increasing Acceleration, Slope of tangent is equal to "$a_{ins.}$"

$\theta_1 = \tan\theta_1 =$ Slope of tangent → $a_{ins.}$

a_{ins} ↑ when θ ↑, tan θ ↑, Slope ↑

∴ Average acc is equal to the slope of chord

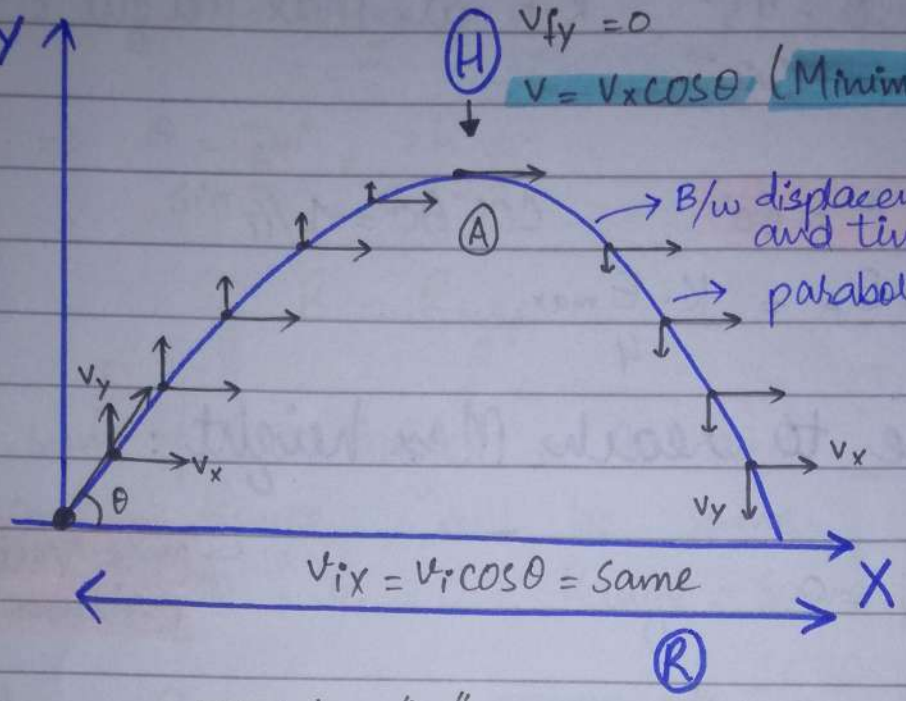
→ V-t graph

① Area is giving → Distance
the parameter Covered

② Slope of the → Acceleration
graph

Projectile Motion.

By Assad Bajwa.



↳ Motion in which "x" component of its velocity remains constant throughout the Motion. i.e $a_x = 0$

↳ Only force Acting is force of gravity

$$F = W$$

$a = g$ → throughout Motion

① v_x = constant

② a_x = Zero.

At point (A)

$$K.E_A = \frac{1}{2} m v_x^2$$

$v_x = v_x \cos\theta$ → Mini Value of "v"

$$K.E = \frac{1}{2} m v_x^2 \cos^2\theta$$

2nd → $K.E = K.E_{max} \cos^2\theta$

$\theta = 45^\circ$

$$= \frac{1}{2} m \left(\frac{1}{\sqrt{2}}\right)^2$$

$$K.E = \frac{1}{2} K.E_{max}$$

∴ A projectile (With K.E = 100 J) is projected at $\theta = 45°$, K.E at Max height ?

Ans = 50 J

$\cos^2 45 = 1/2$

At $\theta = 60°$ $\quad \cos^2 60 = 1/4$

↳ $K.E_A = \frac{K.E_{max}}{4}$

Time to reach Max height :

↳ Max Vertical Distance.

$v_{fy} = 0$

$v_{fy} = v_{iy} - gt$

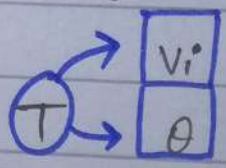
$0 = v_i \sin\theta - gt$

$t_u = \frac{v_i \sin\theta}{g}$

$t_D = \frac{v_i \sin\theta}{g}$

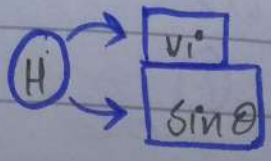
T = Upward + DownWard

$T = \frac{2 v_i \sin\theta}{g}$



Max Height

$H = \frac{u_i \sin^2\theta}{2g}$

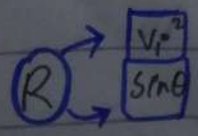


θ ↑ , More Height

Range

$R = v_x T$

$R = v_i \cos\theta \frac{2 v_i \sin\theta}{g} = \frac{v_i^2}{g} \sin 2\theta$



$R = R_{max} \sin 2\theta$

By Assad Bajwa -

→ For what value of θ = ? $R = \frac{R_{max}}{2}$

Magnitude

Value of sin2θ ↓ 30° ↓ 0-5

$\theta = 15°$,

$\sin 2\theta \Rightarrow \theta = 30°$

$\sin 30° = 1/2$

So $R = \frac{R_{max}}{2}$

→ ① If sum of 2 Angles is 90° and ② v_i is same, Range Will be same.

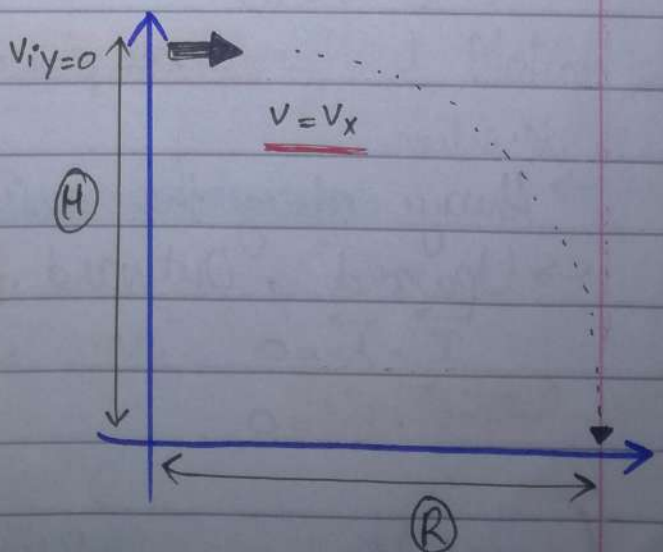
i.e $\theta_1 = 30$, $\theta_2 = 60$, Range = Same for Both.

① $H = \frac{R_{max}}{4}$ at $\theta = 45°$ → If R_{max} → 20m, H → 5m

② $H = R$ → at $\theta = 76°$ or $\tan^{-1} 4$

Free Fall Motions.

Such as a Bomb thrown onto a Building.



① $H = 1/2\, gt^2$

② $T = \sqrt{2H/g}$ ✓

③ $R = u\sqrt{2H/g}$

Freely Falling Body,

→ v - not constant But Constantly increasing.

→ For a pendulum, If θ is substended acc to horizontal $\tau = mgL\cos\theta$

IMCO

Torque → "Moment of Force"

↳ Rotational Analouge of Force.

Zero of

$\theta = 180°$

$\sin 180° = 0$

$F = ma$

$F = 0$, $a = 0$

$F = \Delta P/\Delta t$

$F = 0$, $\Delta P = 0$

P = constant.

↳ Angular acceleration is produced by τ.

$\tau = 0$, ω = constant when

↳ $\alpha = 0$

① Torque due to F_c is Zero.

② " " Central force is Zero.

Torque due to central forces is always Zero

① $\tau = \frac{\Delta L}{\Delta t}$ And ② $\tau = I\alpha$

ΔL → Angular Momentum.

$\tau = 0$, $\Delta L = 0$, L = constant.

$\vec{\tau} = \vec{r} \otimes \vec{F} = rF\sin\theta$

cross product → direction

↳ R.H. Rule

direction

↳ Always along the axis.

↳ Upward, Outward, Anticlockwise → +ve

$\vec{\tau} \cdot \vec{r} = 0$

$\vec{\tau} \cdot \vec{F} = 0$

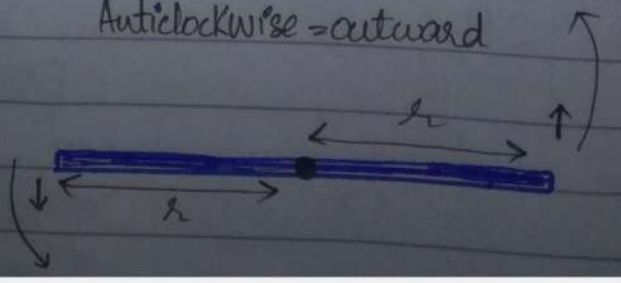
$\therefore \vec{r} \times \vec{F}$ and $-\vec{F} \times \vec{r}$

Angle B/w them is $0°$

Couple

Anticlockwise = outward

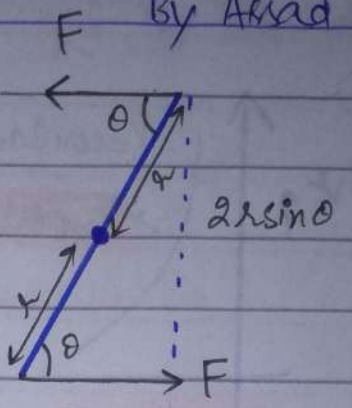
$\tau = 2rF$



By Asad Bajwa.

$\tau = F \times 2r\sin\theta$

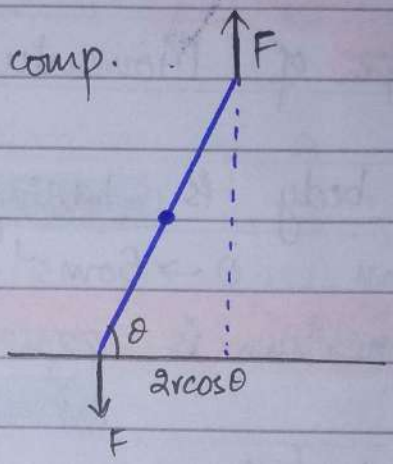
$= 2rF\sin\theta$



→ perpendicular comp.

$\tau = 2r\cos\theta \times F$

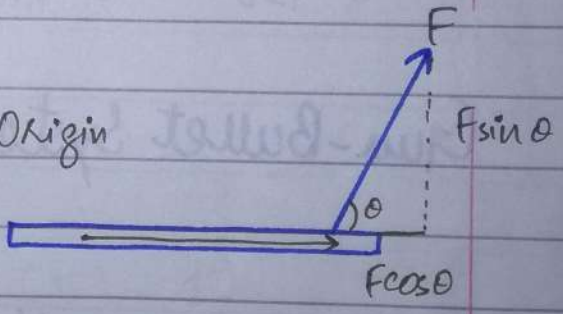
$= 2rF\cos\theta$



$\tau = rF\cos\theta = 0$

↓ passing through Origin

$\tau = rF\sin\theta$ ✓



Momentum

"How easy and difficult it is to stop a moving body."

(*) → Characteristic of a moving Body

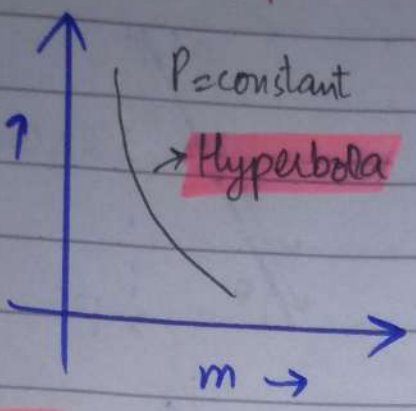
$\vec{P} = m\vec{v}$

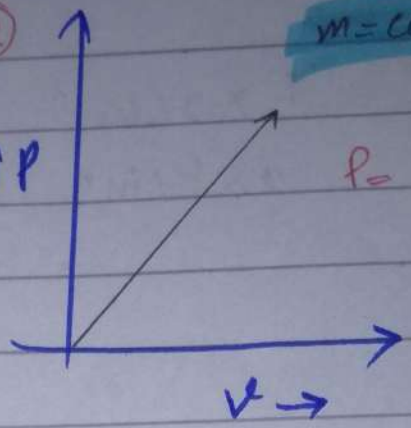
$F = ma = \Delta P/\Delta t$ → More General form of 2nd Law.

2nd Law of Newton

= Ns , $Kgms^{-1}$, $[MLT^{-1}]$, Vector

2p

① 

② 

→ Slope of Momentum time graph → "Force".

A body is falling freely and v changes from $0 \to 50 ms^{-1}$ in time "t", then its Momentum is equal to W → For freely falling Bodies.

$P = W$

$\therefore F = 0$, $mv_f = mv_i = \text{constant}$

Gun-Bullet System

$mv = -MV$

Momentum is same

Velocity is not same.

$M > m$ $\quad V > v$

→ $\frac{m}{M} < 1$

$K.E = P^2/2m$

✱ → 4-particles with same K.E, WOF has Max Momentum (i.e Heaviest)

Electron proton Deutron Alpha Particle ✓

✱ → $\Delta P = 0$, P = constant, Impulse = Zero

Earth's state : ω = constant, L = constant, $\alpha = 0$

Chapter # 03

Work, Energy and Power.

Work — Scalar product / (Dot product)

$W = F \cdot d$

$W = Fd\cos\theta$

$W = W_{max}\cos\theta$ → $\theta = 0^\circ$, $W = W_{max}$, +ve

$W = \frac{W_{max}}{2}$ at $\theta = 60^\circ$ $\cos 60 = 1/2$

$W = 0$ → $\theta = 90^\circ$

(*) → Work done by Magnatic Force is Zero.
↳ simply deflecting force.

→ Scalar

→ $\theta = 90^\circ$; $W = 0$ Work done by "F_c" is Zero.

→ $\theta > 90^\circ$; W = -ve By force of friction

→ $\theta < 90^\circ$; W = +ve Gravitational, Electric force. $\theta = 180^\circ$

→ When constant force is used, Area Under Fd graph (Area of Reactangle) gives Work done.

→ Average i.e Variable force is used, Area of triangle gives Work done $= \frac{1}{2} Fd$.

Power Rate at which Work is done.

E/t , W/t

$$P_{ave} = \frac{\Delta W}{\Delta t} = \frac{\text{Total Work done}}{\text{Total time}}$$

↳ When expressed in terms of constant force acting on a moving object of constant velocity

→ $P = F \cdot V$

↳ Watt-Second → Unit of Energy.

↳ Commercial Unit of energy = Kildwatt hour.

$1\ KWh = 3.6 \times 10^6\ J = 3.6\ MJ = 3600\ KJ$

∴ WOF (not) equal to Watt.

(A) $A.V$

(B) $A^2.Ohm$

(C) J/s

✓ (D) V/A

↳ Area Under power-time Graph → Work done.

↳ Slope of W-t graph gives → power.

∴ 1 horsepower = 746 Watts.

Energy

Capacity to do Work.

Motion

$\frac{1}{2}mv^2 = K.E$

position / Height

$mgh = P.E$

↳ Body may have energy without having Momentum.

$E = \frac{P^2}{2m}$ ∴ $P = \sqrt{2mE}$

Work-Energy Principle.

By Assad Bajwa

→ Law of Conservation of Mass-

Whenever Work is done on a body, It increases its energy -

W = +ve , Along the Force

$W = \Delta K.E$ → Brings change.

W = +ve	W = 0	W = -ve
ΔK.E = +ve, More	ΔK.E = 0	ΔK.E = -ve, less
P.E = less	K.E = constant	P.E = More
Δ.P.E. = -ve	P.E = constant	Δ.P.E. = +ve

→ P.E Will exist → Attraction / Repulsion (Force)

P.E = 0 , If No attraction or repulsion.

Ionized electron has P.E = 0

As free electron.

INTERCONVERSION:

At (A) Max Height

$P.E = mgh$

$K.E = 0$

At point (B) → Mid Way

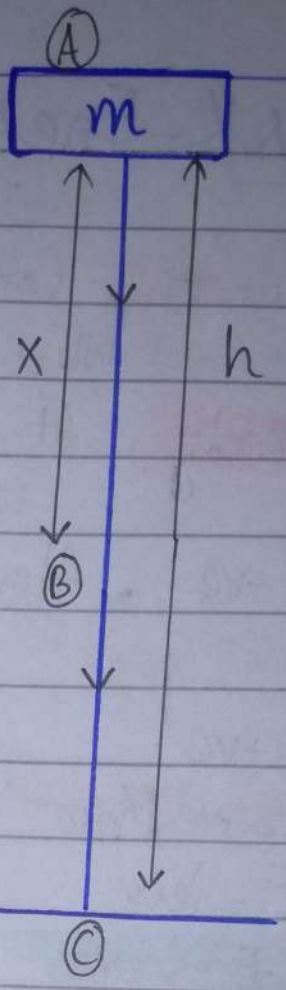
$P.E = mg(h-x)$

→ $K.E = mg(x)$

At (C) → Ground $P.E = 0$, $K.E = mgh$

$T.E = P.E = mgh$

$K.E = 0$



Loss

$P.E_B = mg(h-x)$

$K.E_B = mgx$ ↳ Gain

partially P.E + partially K.E

$P.E_c = 0$

$T.E = K.E_c = mgh$

just Before stricking

Loss in P.E = Gain in K.E

↑ Ideally

↳ After stricking, $K.E = 0$, $P.E = 0$

Height = 0, But T.E = constant

* $T.E = mgh$

$\therefore v_B^2 = 2gx$

$\therefore v_c^2 = 2gh$

With friction

Loss in $P.E - fh$ = Gain in K.E

$mgh - fh = \frac{1}{2}mv^2$

$mgh = \frac{1}{2}mv^2 + fh$ → For downward

$\frac{1}{2}mv^2 = mgh + fh$ → For upward.

Topic # 04

By Assad Bajwa -

Circular Motion -

"Movement in which distance of particle from a fixed point remains same."

Fixed point → Center

→ line passing through center and Normal to plane is called axis.

ANGULAR

Displacement : $\Delta\theta$

→ Vector ✓

→ Always along the axis → direction ✓

→ Dimensionless, S.I unit → Radian

→ Direction by Right Hand Rule -

→ Upward / outside / Anticlockwise → +ve

For smaller values of θ, angular displacement is Vector -

$\therefore S = r\theta$

$\therefore$ Arc = 1r = 1 rad

$\therefore$ Arc = 2r = 2 rad

$\theta \propto S$

→ Relation b/w Angular and linear displacement -

→ Angle B/w Angular and linear displacement is 90°. or $\pi/2$ rad.

Directed → linear → Along tangent } in a circle

Angular → Along Axis

"θ" b/w Axis and tangent is 90°.

1 revolution = 2π rad = 360°

1 rad = 57.3° → 2nd

Velocity

$\omega_{ave} = \frac{\Delta\theta}{\Delta t}$ $\quad \frac{\text{Rad s}^{-1}}{[T^{-1}]}$ / Revolution per Minute

$\omega \curvearrowright \theta$

θ → Anticlockwise

ω → Anticlockwise.

Acceleration

$\alpha_{av} = \frac{\Delta\omega}{\Delta t}$ $\quad \frac{\text{Rad s}^{-2}}{[T^{-2}]}$

① → If ω increases

ω and α are parallel

ω : Anticlockwise

α : Anticlockwise

② → If ω decreases

ω and α are antiparallel.

$\therefore a_t = r\alpha$

tangential Acceleration.

$\vec{a}_t = \vec{r} \times \vec{\alpha}$

Right Hand Rule

① $\alpha \perp a_t$

② $r \perp a_t$

③ plane containing Both.

$(\vec{\alpha} \times \vec{r}) \cdot \vec{\alpha} = ?$

$\vec{a}_t \cdot \vec{\alpha} = 0$

$\therefore$ Dot product of perpendicular Vectors is Zero.

Angular and linear Velocity

By Assad Bajwa

$v = r\omega$

$\vec{v} = \vec{r} \times \vec{\omega}$ ~~$\vec{v} = \vec{r} \times \vec{\omega}$~~ ✓

Cross product, so

$v \perp \omega$

$v \perp r$

Angle B/w v and ω is always 90°

"v" → tangential Velocity. (linear) → Acts along the tangent.

CENTRIPETAL FORCE-

① → towards the center of circle.

② → Along the radius

→ $F \perp v$ → At any point

Only direction will be changed $\theta = 90^\circ$

↳ of Velocity.

$$a_c = \frac{v^2}{r} = r\omega^2 \rightarrow (*)$$

↓

Directed along the radius towards the Center of circle.

$$F_c = ma_c = \frac{mv^2}{r}$$

① $F \propto 1/r$ when speed is same in 2 diff radii.

$$F_c = mr\omega^2$$

② $F_c \propto r$: when linear speed is not same

∴ Uniform speed, ω = constant, $\alpha = 0$ ✓ v. imp

$a_t = 0$, $\tau = 0$, Only Acc is $a_c = v^2/r$

↳ Normal Acceleration.

Geostationary Satellite -

↳ Geo-Synchronous, Geo-stationary

→ Orbital Motion is synchronized with rotation (spinning) of earth.

$$v = \sqrt{\frac{GM}{r}} \quad v \propto \frac{1}{\sqrt{r}}$$

→ Average speed of satellite in one day.

∵ $V = r\omega$ → same

→ $v \propto r$ $v \uparrow, r \uparrow$ when T = same.

↳ For Geo stationary satelite

$$\frac{2\pi r}{t} = \sqrt{\frac{GM}{r}}$$

$$\frac{4\pi^2 r^2}{t^2} = \frac{GM}{r}$$

$$r^3 = \frac{GMT^2}{4\pi^2} \rightarrow r^3 \propto T^2$$

$$r = \left[\frac{GMT^2}{4\pi^2}\right]^{1/3}$$

$r = 4.23 \times 10^4$ Km

$= 42300$ Km $= 4.23 \times 10^7$ m

∴ $R + h = 36000$ Km

Mini → 3 at 120° each $v = 3.1$ Km/s

∴ Closest Orbit

400 Km, $v = 7.9$ Km/s, $T = 84$ min $= 5060$ s

→ Mean to half of extreme = T/12
→ Extreme to half of Mean = T/6

Chapter # 7 "Oscillations"

↳ 3MCQ's-

① ↳ Oscillatory Motions Must be periodic
② ↳ Periodic May/May not be Oscillatory.
↳ Circular Motions are periodic But Not SHM.

SHM can be stated as $a \propto -x$ → Graph is straight line
↳ acc and F_c → toward Mean position -

$F_R = -Kx$

$K = Kgm^{-2}$

$F_R \propto -x$ → straight line graph.
↳ towards Mean position -

↳ Displacement in General ⇒ $x = x_0 \sin\theta$

$\sin\theta = x/x_0$

2nd ✓

↳ SHM starting from +ve extreme
↳ $x = x_0 \cos\theta$
-ve extreme
↳ $x = -x_0 \cos\theta$

↳ Velocity in SHM

$v = \boxed{x_0\omega}\cos\theta$
v_{Max}

$v_i = v_{Max}\cos\theta$

$v_{ins} = v_0 \cos\theta$

→ Max Velocity

$v_0 = x_0\omega$

$\boxed{v_0 \propto x_0}$

Max speed of SHM
↳ $V_0 = \frac{2\pi A}{T}$ (MCAT Q)

↳ Value at an instant

$v = \omega\sqrt{x_0^2 - x^2}$ → MCAT Exam 2015/14

At Mean ⇒ $x = 0$ At Extreme ⇒ $x = x_0$

$v_0 = x_0\omega$ → Max $v = 0$ → Mini.

↳ Acceleration

$$a \propto -X$$

Basic $a = -\omega^2 X$

For Max $a_0 = -\omega^2 X_0$

$\therefore$ at extreme $X = X_0$

$a = \boxed{-X_0\omega^2} \sin\theta$

$\theta = 90° \rightarrow$ at extreme.

$a_{max} = -X_0\omega^2 \rightarrow \quad a_0 \propto X_0$

$a_{ins} = a_{max} \sin\theta$

↳ PHASE

Tells ① displacement as well as ② direction of Motion of point executing SHM.

$X = X_0 \sin\theta$

$X = X_0 \sin(\omega t + \phi)$ → initial phase.

If $\phi = 90°/\pi/2$ i.e Motion is being started by the object at Extreme.

$X = X_0[\sin(\omega t + 90°)] = \cos\theta$

"$X = X_0 \cos\theta$"

↳ Mass Spring System:

Horizontal $\rightarrow \omega = \sqrt{K/m}$

$T = 2\pi\sqrt{m/K}$ $\boxed{T \propto \sqrt{m}}$

$v = \omega\sqrt{X_0^2 - X^2}$ → instantaneous.

↳ $v_0 = X_0\sqrt{K/m}$ → Max Value

↳ $v = v_0\sqrt{1 - X^2/X_0^2}$ ← $\frac{2}{4}$ → instantaneous

$\rightarrow K/m = g/\ell$

By Assad Bajwa

Vertical $F = Kx$

$F = mg$

$mg = Kx$

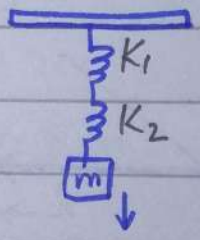
$m/K = x/g$

x/g is always same No matter how "g" Varies

$T = 2\pi\sqrt{x/g}$ $\quad f = 1/2\pi\sqrt{g/x}$

Combination of Springs

Series $= 1/Ke = 1/K_1 + 1/K_2$



$\underline{Ke} = \dfrac{K_1K_2}{K_1+K_2}$

For "n" springs With same K $\Rightarrow$ Ke $= K/n$

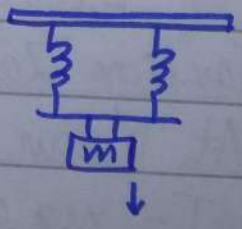
Ke (↓ Mini) $< K_1$, $Ke < K_2$

Parallel $Ke = K_1 + K_2 = 2K$

$Ke = nK$

(↓ Max)

$\hookrightarrow Ke > K_1$, $Ke > K_2$

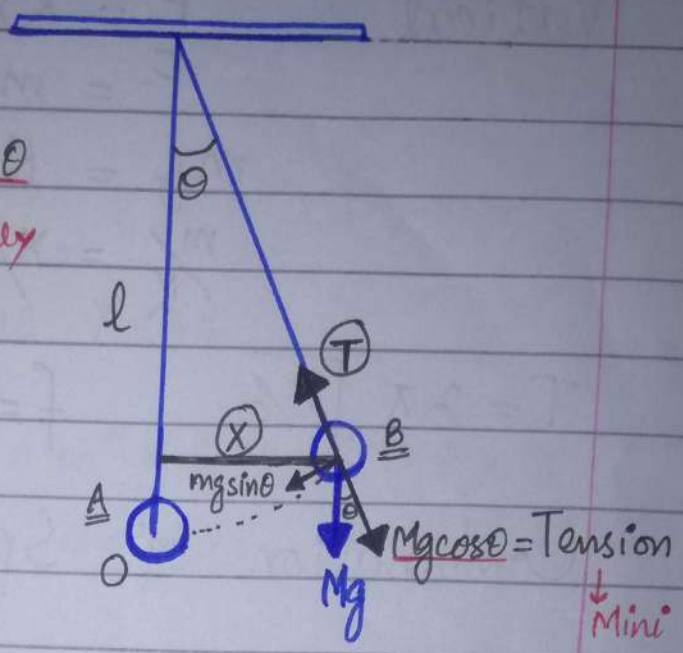


$\therefore$ If $K = 2K \rightarrow T' = T/\sqrt{2}$ ← Imp

→ A spring of spring Constant "K" is cut into 2 equal parts, spring constant of each part will be → 2K

If "n" equal parts, each part → nK.

Simple Pendulum:



Restoring Force = $-mg\sin\theta$

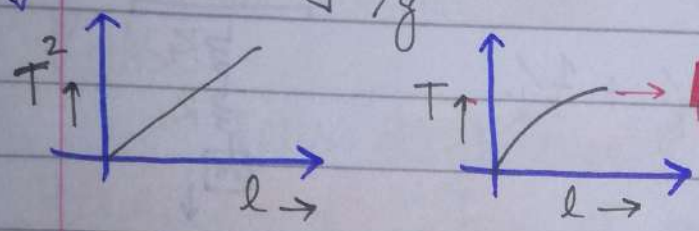
Generally

$a = -g/l \, (x)$

Direction

$g/l = K \rightarrow$ Constant

$T = 2\pi\sqrt{l/g}$



→ Tension will be Mini at extreme

$T = mg\cos\theta$ $\quad \theta\uparrow, T\downarrow$

Un essential → $\theta = 90°$ at Mean/ Extreme/Both/None ✓ $\quad \boxed{\cos 90° = 0}$

→ Tension Zero Only When It's perpendicular

∴ At Mean $\theta = 0°$

$T = mg\cos 0° = mg = W = \text{Max.}$

↳ at Height of point i.e $\theta = 90°$

↳ Time period Max → at equator and Mini → at poles.

↳ g → Mini

↳ g → Max

↳ In a freely falling system, For Simple pendulum

$T = \infty$, $\boxed{f = 0}$

as $g = a$

↳ such that a second pendulum is at height $R = 3R$ of earth i.e $T = \infty$, $g = 0$

By Assad Bajwa

→ Second Pendulum

$T = 2s$

$f = 0.5\ Hz$

$l = 0.99m \approx 1m$

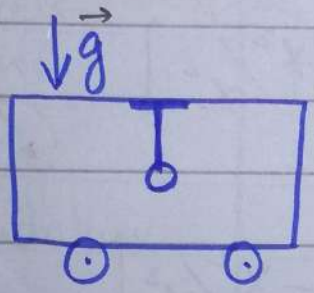
∴ When taken to Moon, T will be same.

$g/6 : l/6$

Ratio is fixed.

length at Earth = 1m

length at Moon = 1/6 m

① 

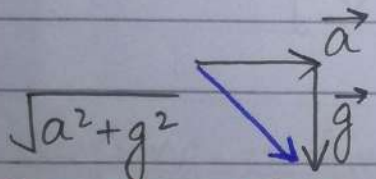
Time period = ?

✗ (A) Increase

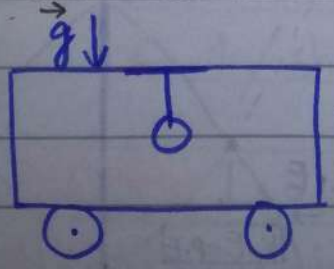
✓ (B) decrease

✗ (C) Remain Same

✗ (D) None.

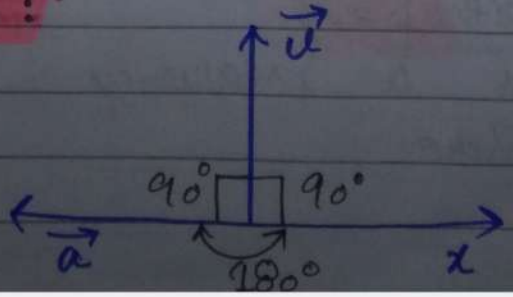


Effective Value of "g" increased, time period will decrease.

② 

Time period Will Remain Same → No change in "g"

Relations : ✓



→ K.E = 2E, not possible

Ratio $v/d = \frac{\omega x_0}{x_0} = \omega$

$\frac{a}{d} = \frac{\omega^2 x_0}{x_0} = \omega^2$

→ Energy Conservation:

$P.E = \frac{1}{2} K x^2$ → Basic

↳ Elastic

$P.E_{max} = \frac{1}{2} K x_0^2$ → proportional to square of amplitude

$P.E_0 \propto x_0$

$a_0 \propto x_0$

$v_0 \propto x_0$

$K.E = \frac{1}{2} K x_0^2 \left[1 - x^2/x_0^2\right]$

→ Time at which $x = A/\sqrt{2}$ is $t = T/8$

$K.E_{max} = \frac{1}{2} K x_0^2$

$K.E_{ins} = K.E_{max} \left[1 - x^2/x_0^2\right]$

$E_{total} = P.E + K.E$

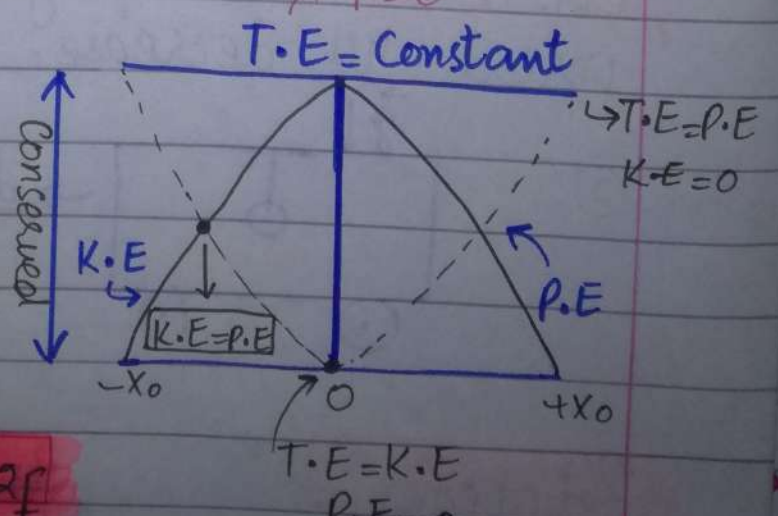
$T.E = \frac{1}{2} K x_0^2$

During SHM,

* $P.E = K.E$

at $x = 0.707 x_0$

at $\theta = 45°$



2f → K.E and P.E oscillates with $f = 2f$ and T.E has a frequency equal to Zero.

Free and forced Oscillations.

→ Driven Harmonic Oscillator oscillates With frequency of "force"
↳ applied.

↳ Amplitude of D.H.O depends upon the "Amplitude of Applied force."

↳ In Rasonance, energy of oscillations comes from driving force.

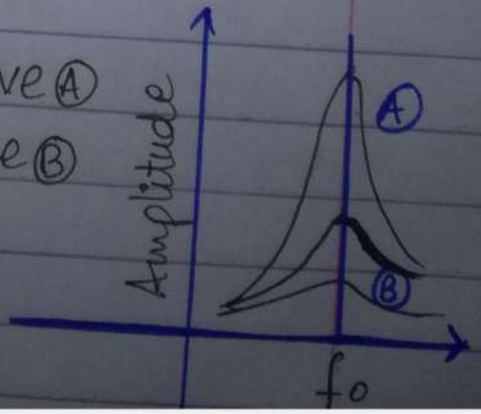
↳ At rasonance, amplitude & energy → Max

Mechanical	Electrical
→ Swing	Tunning of Radio
→ Hanging Bridge	→ Microwave oven
→ Simple pendulum	λ = 12cm → of Microwaves.
	f = 2450MHz.

Damping → Amplitude gradually decreases.

① Damping $\propto$ 1/Amplitude
② Damping $\propto$ 1/sharpness.

→ Damping Small → sharp Curve Ⓐ
→ Damping large → Flat Curve Ⓑ

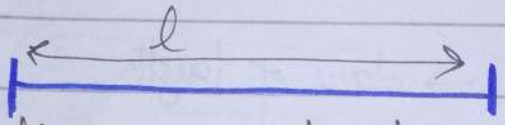


Chapter #8 Waves → Transverse can travel in gases but not in Metal.

Stationary Waves: When two waves of same speed and wavelength overlap from opposite side, stationery waves are formed and No Energy is transformed.

↳ Permanent rest points : Nodes

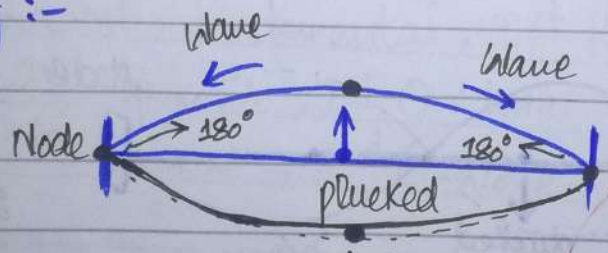
↳ permanent Vibrating points : Antinodes.



linear mass density = m

$u = \sqrt{F/m}$ transverse stationery Waves.

Stretched String :-



Node = Rest point
u = zero
Amplitude = zero
load = Max here.

u = Max
Amplitude = Max
Stress = Min

↳ Plucked from Center = 1 loop

Node to node = $\lambda/2 = l$

Node to Antinode = $\lambda/4 = l$

$\lambda_n = \frac{2l}{n}$

$\lambda_n \propto \frac{1}{n}$

$\lambda \downarrow$, $n \uparrow$

Case-I :

For the above given case

$\lambda_1/2 = l$

$\lambda_1 = 2l$

And $u_1 = f_1 \lambda_1$

$f_1 = v_1 / \lambda_1$

$f_1 = u_1 / 2l$

→ Lowest value of "f".
→ Ist Harmonic
→ Fundamental Frequency

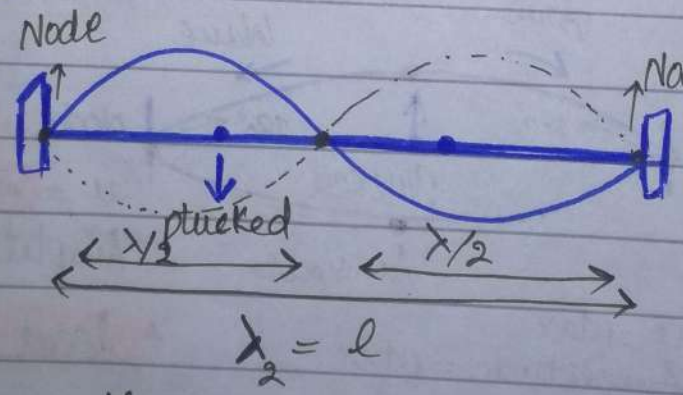
$f_1 = \frac{1}{2l}\sqrt{F/m}$

$f \propto \frac{1}{l}$ → law of length

$f \propto \sqrt{F}$ → law of tension f↑, F↑

$F \propto \frac{1}{\sqrt{m}}$ → Law of Mass.

Case - II



$\lambda_2 = l$

$f_2 = u/\lambda_2 = u/l$

$f_2 = 2(u/2l)$

$f_2 = 2 f_1$

2 AntiNodes
3 Nodes.
↓
plucked from $l = \frac{1}{4} l$

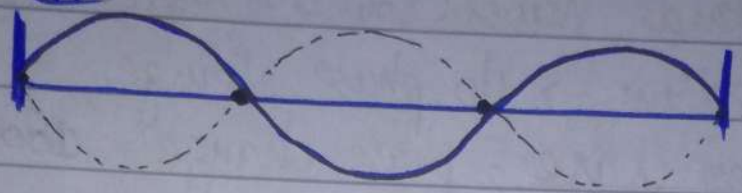
→ loops increasing ✓
→ Wave length decreasing
→ freq increasing

$\therefore \lambda_1 = 2l$
$\lambda_2 = l$ Half

$\boxed{\lambda_1/2 = \lambda_2}$

By Assad Bajwa -

Case - III



4 Nodes
3 AntiNodes -

$$\frac{3\lambda_3}{2} = l$$

$$\lambda_3 = 2l/3 \qquad \therefore \lambda_1 = 2l$$

$$\lambda_3 = \lambda_1/3$$

$$f_3 = 3f_1$$

Generally

$$f_n = n f_1 \quad \text{And} \quad \lambda_n = \lambda_1/n$$

$f_1 \rightarrow$ Lowest, fundamental, 1st Harmonic.
$f_2 \rightarrow 2^{nd}$ Harmonic, 1st Overtone.
$f_3 \rightarrow 3^{rd}$ Harmonic, 2^{nd} Overtone.

Stationary Waves in Air Column

→ Organ pipe

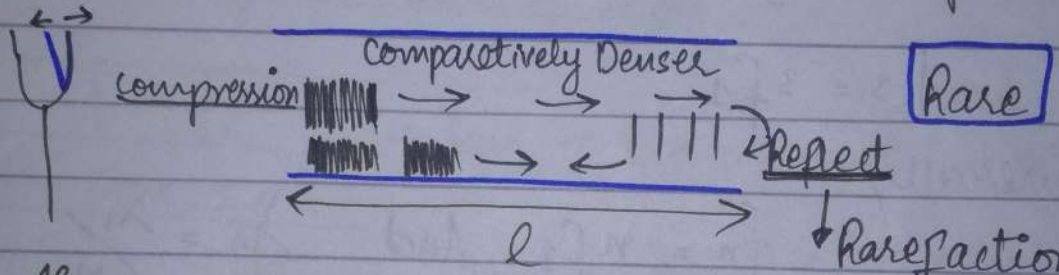
"Wind instrument in which sound/stationary waves are produced due to overlapping of incident and reflected waves."

- Open Organ pipe
- Closed organ pipe -

→ Longitudinal Waves (sound) reflect from denser Medium → No phase change.
→ If from rare, phase change 180° and path difference $\pi/2$ and vice versa for transverse Waves.

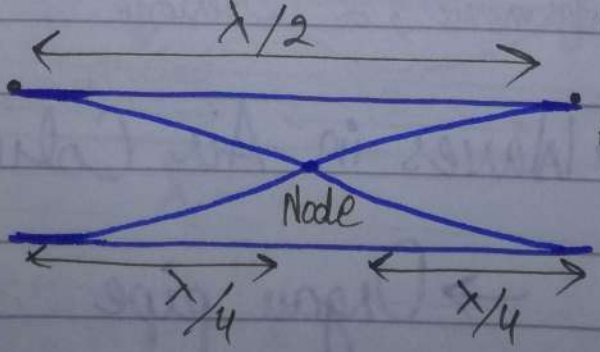
Open Organ pipe:

Antinode at the open end.



If rarefaction overlap compression → destructive
If rarefaction overlap rarefaction → constructive
↓
Loudness.

Case - I



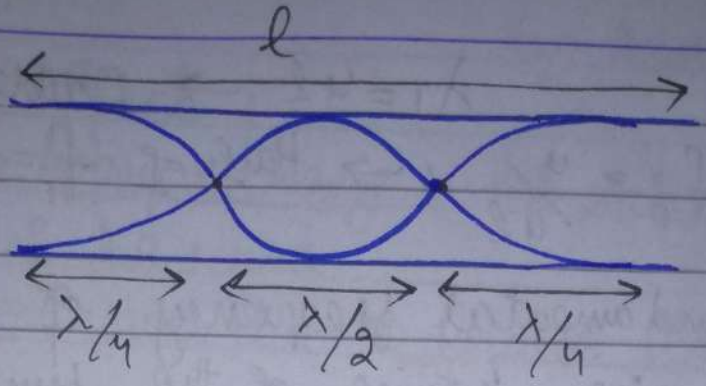
Temperature is decreased
↳ frequency is also decreased

$\lambda_1 = 2l$, $f_1 = v/2l$

$v = \sqrt{F/m} = \sqrt{\frac{\gamma P}{\rho}}$ → For speed of sound as here, no stretching.

So for speed, this expression would be used.

Case - II



$$\lambda_2 = l$$

$$\lambda_2 = \frac{2l}{2} = \frac{\lambda_1}{2}$$

$$f_2 = 2f_1$$

f_1 = Fundamental, Ist Harmonic

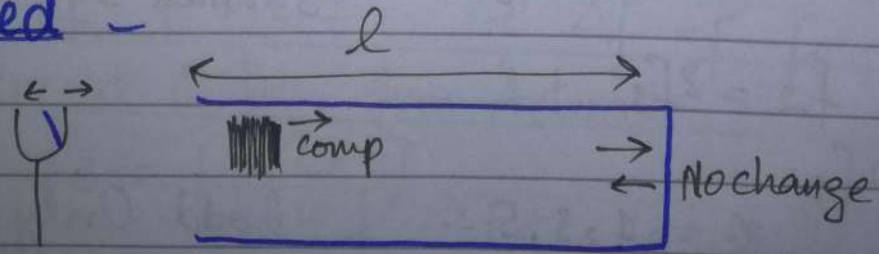
$$f_n = n f_1 \qquad n = 1, 2, 3, 4 \ldots$$

$$\lambda_n = \frac{\lambda_1}{n}$$

→ Both Ends closed, Both Ends ~~closed~~ open
Both Even and odd harmonics will be present.

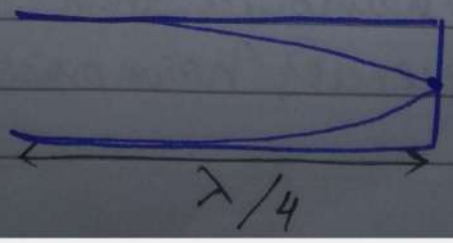
→ Here AntiNodes > Nodes → open organ pipe.

Closed -



Rarefaction overlap compression.

Case - I



→ For closed fundamental is 25 Hz
for open it would be 50 Hz.

$\lambda_1 = 4l \rightarrow$ Doubled

$f_1 = v/4l \rightarrow$ Half of $f_1 = v/2l$

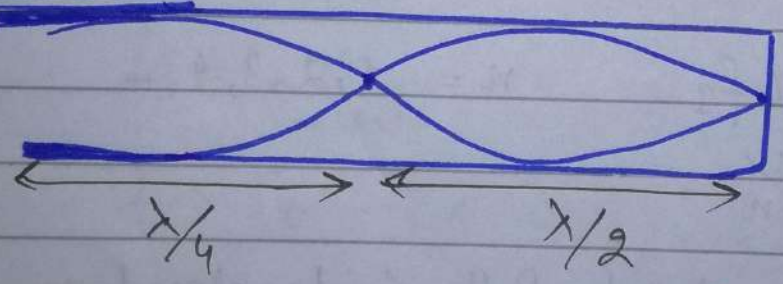
→ Fundamental frequency of open organ pipe is twice of the fundamental frequency of closed organ pipe. $f_{open} = 2 f_{closed}$

closed organ pipe has lesser "f"

$f_{closed} = 2 f_{open}$

→ No rule of Antinode or Node here. Any of them can be greater in #.

Case - II :



$l = 3/4 \lambda_2$

$\lambda_2 = 4/3 l$

$\lambda_2 = \lambda_1/3$

1 - third $= \lambda_2$

3 - times $= f_2$

$f_1 \rightarrow 1^{st}$ Harmonic

$3f_1 \rightarrow 3^{rd}$ Harmonic

$5f_1 \rightarrow 5^{th}$ Harmonic

↓ even Harmonics are Missing

$f_2 = 3f_1$

$f_n = n f_1$

$n = 1, 3, 5 \ldots$ (odd Only)

→ open organ pipe is More rich in frequencies/harmonics than closed pipe.

→ More frequencies/harmonics → pure Music.

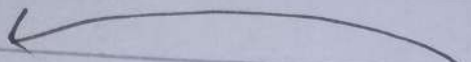
Doppler effect :

By Assad Bajwa.

→ Apparent change in the pitch / frequency of the sound.

→ Occurs due to Relative Motion

Case - I



Source. Observer

static

$$f_A = \left(\frac{u+u_0}{u}\right) f$$

$$\Delta f = f_A - f \quad \text{i.e} \quad f_A > f$$

Apparent is More than Actual.

Case - II

Source. Observer →

static

$$f_B = \left(\frac{u-u_0}{u}\right) f$$

$$f_B < f \quad \text{i.e} \quad \Delta f = f - f_B$$

Apparent is less than Actual.

$$f_B = f - \left(\frac{u_0}{u} f\right)$$ → Extra Waves Not received.

Case - III

Source → Observer.

Static

$\Delta\lambda = \lambda - \Delta\lambda$ (Wavelength is decreased here).

u_s ↓

$f \rightarrow$ doppler shift

$$fc = \left(\frac{u}{u - u_s}\right) f$$

$$\Delta f = fc - f \quad i.e \quad fc > f$$

Case - IV

← Source Observer • static

$\Delta\lambda = \lambda + \Delta\lambda \rightarrow$ Wavelength increased.

$$fd = \left(\frac{u}{u + u_s}\right) f$$

$$f > f_D \quad i.e \quad \Delta f = f - f_D -$$

→ When Observer Moves, Doppler shift → Relative Motion

→ When source Moves, It is due to → $\Delta\lambda$.

$u_o \rightarrow$ $u_s \rightarrow$ $f' = \left(\frac{v + u_o}{v + u_s}\right) f$	$u_s \rightarrow$ $u_o \rightarrow$ $f' = \left(\frac{u - u_o}{u - u_s}\right) f$
$u_o \rightarrow$ $u_s \leftarrow$ $f' = \left(\frac{u + u_o}{v - u_s}\right) f$	$u_o \leftarrow$ $u_s \rightarrow$ $f' = \left(\frac{u - u_o}{v + u_s}\right) f$

By Assad Bajwa.

Unit # 5. Light:

Type of Energy produces sensation of vision.

→ Low frequency → Waves (High Wavelength)

→ High frequency → particles (shorter Wavelength)

→ phase diff B/w two points at a wavefront is "zero" → in phase → same phase of Vibration.

→ Distance b/w consecutive Wavefronts is "λ" → 1 Wavelength.

→ Angle B/w plane Wavefront and ray ↓ direction of propagation of Wave.

→ Rays are parallel for plane Wavefront.

→ Wavefronts from sun reaching earth are plane.

→ point source → spherical Wavefronts.
point source at infinity → plane Wavefronts.

v.2p TO Get a →

→ Plane Wavefront: place point source at the focus of convex lense.

→ No. of see sources on a wavefront are "infinity."

→ see. Wavefront: Tangent to all see. Wavelets.

→ Hygen's principle: ① shape and ② location of Newly formed Wavefront.

→ Hygen → First theoratically proposed wave nature of light.

→ Distance B/w two consecutive wavefronts (plane/spherical) in time "t" is $c\Delta t$.

→ Wavelets are always spherical.

INTERFERENCE

* → Intensity $\propto$ (Amplitude)^2

: phase diff → 2π, 4π, 6π

→ constructive : path diff → $0, \lambda, 2\lambda, 3\lambda$ ~~$0, \lambda, 2\pi$~~ ..

→ Destructive → $\lambda/2, 3\lambda/2$ ...

↳ intensity and amplitude Mini - (Both Mini)

Coherent ① ← Conditions → ② Monochromatic

→ YOUNG → First experimentally proved Wave Nature of light.

→ In this, wavefronts are splitted for Coherent sources.

→ For observable interference, exp is used.

→ Mid point → Bright Band/Zeroth/Central/Principle.

(1) → $d\sin\theta = n\lambda$

$n = 0, 1, 2$

$m=0$
Central Bright

$m=0$
First dark. ✓

∴ Value of m matters alot.

(2) → $d\sin\theta = \left(n+\frac{1}{2}\right)\lambda$

→ "There is no central dark."

→ Distance B/w 3rd and 4th & 15th and 16th Bright Band is same.

(3) →

$Y = \frac{m\lambda L}{d}$ → distance B/w mth Bright Band and Central Maxima.

(4) → $Y = \left(m+\frac{1}{2}\right)\lambda L/d$ → " " mth dark and Central Maxima.

(5) $\Delta Y = \lambda L/d$

↳ fring spacing, consecutive Bright and dark Bands.

$\Delta Y = \lambda L/2d$ → spacing B/w dark and Bright.

→ Light enters Any denser Med, speed decreases

$v = c/n$, n times reduced.

↳ refractive index of the Medium.

$\frac{v_1}{v_2} = \frac{n_2}{n_1}$ "f" remain same.

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DIFRACTION GRATING.

→ Glass plate : Mechanically ruled slits.

→ Typical diffraction Grating 400 – 5000 lines / cm.

d = Grating Element = $\frac{1\text{ cm}}{5000} = 2 \times 10^{-6}\text{ m}$

can be made small by increasing # of slits i.e $d = \frac{1}{n}$.

$d \sin\theta = n\lambda$ (2nd)

$n = 0, \pm 1, \pm 2 \ldots$

$\theta = 0°$, Zero Order image.

$\theta = 90°$, $\sin\theta = 1$ FOR Highest Maxima.

$\frac{n\lambda}{d} = \sin\theta$

Optical fiber : → should be **total internal reflection** Principle

$n = c/v$

$\theta_1 = \theta_c$, $\theta_2 = 90°$

Air = 1

Glass = 3/2

Value of Angle of incident for which angle of reflection becomes 90° is called critical Angle.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 \sin\theta_c = n_2$

$\sin\theta_c = \frac{n_2}{n_1}$ → lighter

n_1 → denser.

Total internal Reflection

① $\theta_i > \theta_c$ ✓

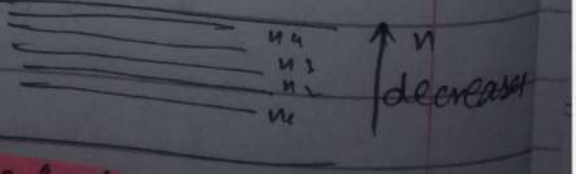
② Denser to lighter propagation.

Continuous Refraction

Denser → lighter → propagation

$n_1 > n_2$

$n_2 > n_3$



→ core, More dense, More "n".

Unit # 06

HEAT AND THERMODYNAMICS.

→ Macroscopic approach: KMT → discuss Motion of gas Molecules.

→ B/w two successive collisions, path is straight.

→ Collision is perfectly elastic, Motion is random.

$$P = \frac{\Delta P / \Delta t}{A} = \frac{\Delta P}{A\,\Delta t}$$

(ΔP: change in Momentum)

* Pressure ∝ # of collisions.

For cube $A = l^2$ $V = l^3$

→ Change in Momentum = $-2mv$

$$\frac{\Delta P}{\Delta t} = \frac{mv^2}{l}$$

→ $t = s/v \Rightarrow \Delta t = \frac{2l}{v}$ → time B/w 2 impacts.

→ Density = $\rho = \frac{mN}{l^3} \rightarrow \boxed{\frac{mN}{A^3}}$ MCAT Qs.

for N particles

$$\frac{m}{l^3} = \frac{\rho}{N}$$

→ Mean of squared velocities = $\frac{v_{1x}^2 + v_{2x}^2 + v_{3x}^2 \dots v_{Nx}^2}{N}$

can't be Zero. Mean "v" can be zero.

→ Generally: $P = \frac{1}{3}\rho \langle v^2 \rangle$ MCAT Question.

pressure is given by

pressure double

① $P \propto \rho$

② $P \propto \langle v^2 \rangle$ → Mean square "v" → double

③ $P \propto v^2$ → Mean speed → double ✓

pressure double / 4-times. ✓

→ $P = \frac{2}{3} \frac{N}{V} \langle \frac{1}{2} m v^2 \rangle$ MCAT Qs

$\boxed{P = \frac{2}{3} E}$ ← 2mp

→ $R = 8.314\ J\,mol^{-1}K^{-1}$ (MCAT Q's)

* → $\frac{N}{n} = N_A$ = No. of Molecules / Mole (MCAT Q's)

→ $K = \frac{R}{N_A}$ → Boltzman Constant (MCAT Q 2018)

$1.38 \times 10^{-23}\ JK^{-1}$ ✓

↳ Gas Constant per Molecule

→ $T = \frac{2}{3K} \langle \frac{1}{2} m v^2 \rangle$

$\therefore T$ = same

$\therefore \langle K.E \rangle$ = same

$P \propto \langle K.E \rangle$

$T \propto \langle K.E \rangle$

$P \propto T$

2mp

$\therefore$ Translational $K.E = \frac{3}{2} KT$

→ $C_{rms} = \sqrt{\frac{3KT}{M}} = \sqrt{\frac{3P}{\rho}}$

2mp Does not changes with expansion/compression

By Asrad Bajwa -

INTERNAL ENERGY

→ Sum of all types of energies.

→ For ideal Gas

Internal Energy = Translational K.E

∴ $U \propto K.E \propto T$

Heat

Substance

↳ Molecular Motion increases

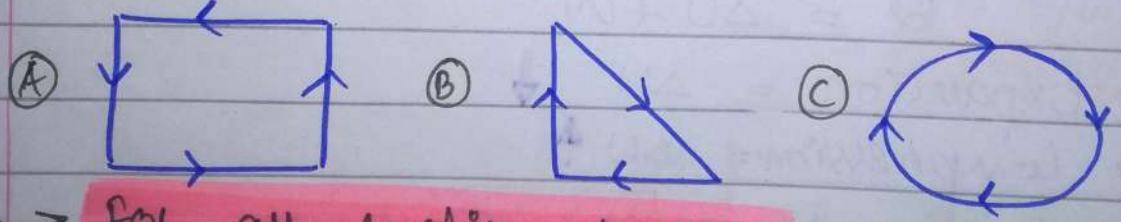
↳ K.E ↑

↳ Temperature ↑

↳ U ↑ ⟶ , ΔU = +ve

2) When T = constant

↳ U = Constant And $\Delta U = 0$



→ For all cyclic processes $\Delta U = 0$

U = Constant.

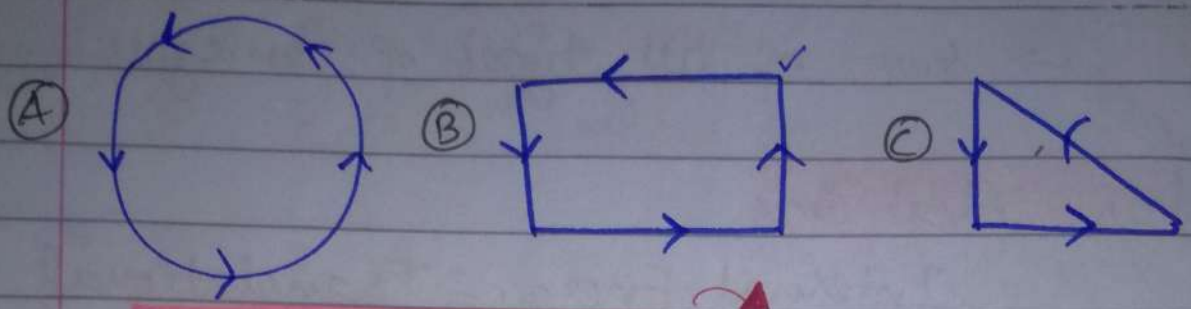
WORK AND HEAT

→ Heat in (+ve) (Given to)

→ Work out (+ve) (By the System)

→ Area Under PV-graph; Work done.

$W = P\Delta V$



→ For cyclic processes $W \neq 0$

→ Heat is Mechanical energy and depends upon ΔU and Work done.

W = +ve → Work by the system.
Expansion
$V_2 > V_1$

W = -ve → Work on the system.
Compression
$V_1 > V_2$

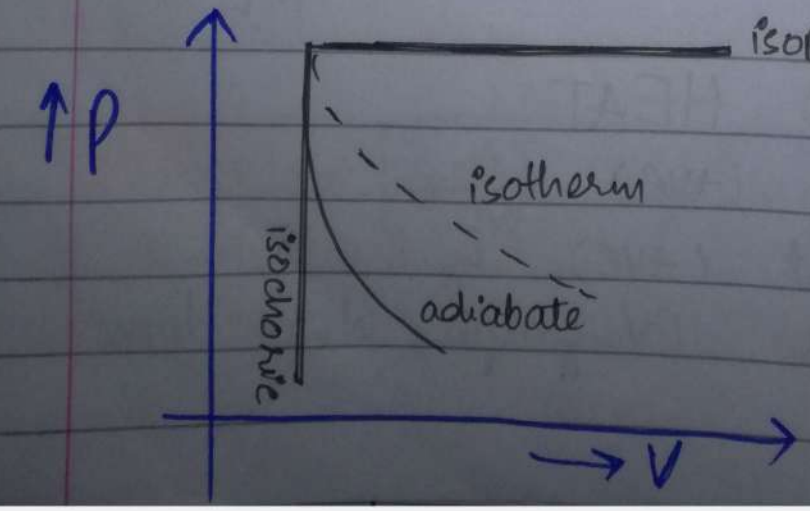
Ist Law of thermodynamics.

↳ Law of conservation of energy.

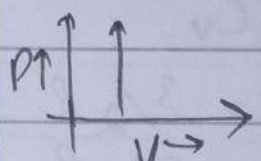
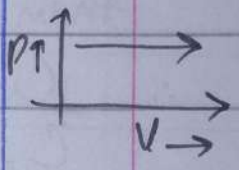
$$Q = \Delta U + W$$

In General → Expansion = ΔU ↓
→ Compression = ΔU ↑

→ Thermocouple → Abrupt change in air temp. is Monitered.



→ Heat goes out when compressed.
→ Work done on the system → Heat goes out to Maintain Temperature.

Isothermal	Adiabatic	Isochoric	IsoBarie
→ T = constant U = constant	$Q = 0$	$\Delta V = 0$ $W = 0$	$\Delta P = 0$
→ $\Delta T = 0$ $\Delta U = 0$	$W = -\Delta U$ → expansion $-W = \Delta U$ → compression	$\Delta Q = \Delta U$ $Q_v = \Delta U$	$Q = \Delta U + W$
→ $Q = W$	Mini / Zero "W" is done.	Max "W" is done in isoBaric.	
→ slow change	Abrupt change		
PV = Constant Boyl's Law.	PV^{γ} = constant ↳ Boyl's Law		

Work done

IsoBaric > Isothermal > Adiabatic > isochoric

↳ Greatest

No extra heat is to be given → ← No work is to be done.

→ $\Delta V = 0$ → isochoric is More economical.

$\Delta U = C_v \Delta T$

↓ But

$\Delta U_p = \Delta U_c$

→ IsoBaric

$Q_p = C_p \Delta T$

→ For same rise in temperature in Q_v and Q_p

Imp Q_p → More heat should be supplied.

↳ Extra heat → Work is done

→ Derivation

→ $W = R \Delta T$ It is also Work done.

$C_p - C_v = R$

i.e $C_p > C_v$ By an amount equal to "R".

→ Generally $\therefore C_v = \frac{R}{\gamma - 1}$ 2nd

Highest for Monoatomic

$\gamma = \frac{C_p}{C_v}$ $\therefore \gamma > 1$

→ C_p will always be 1 R greater than C_v.

$\therefore C_v = 3/2 R$

$C_p = 5/2 R$

$\gamma = \frac{C_p}{C_v} = 1.5$ ✓

∴ Given that $C_p = ?$ $C_v = ?$

$\gamma = 1.5$

$C_p = \gamma C_v$

⟶ As $C_p - C_v = R$

$1.5 C_v - C_v = R$

$C_v (1.5 - 1) = R$

$C_v (1/2) = R$

$C_v = 2R$

As C_p is always 1R greater, $C_p = 3R$.

2nd

→ Triple point of Water

$\frac{T}{T_{TP}} = \frac{Q}{Q_{TP}}$

1/273.16 of T of triple point of Water is "1 K"

$T = T_{TP} \frac{Q}{Q_{TP}} \Rightarrow T = 273.16 \times \frac{Q}{Q_{TP}}$

Electrostatics

Coulomb's Force :-

$F \propto \frac{q_1 q_2}{r^2} = K \frac{q_1 q_2}{r^2}$ (K → constant)

Attractive and Repulsive Both

① Medium dependant

② Mutual force → "F"

→ Coulomb's Law → Newton's 3rd Law of Motion.
↳ Applicable on point charge!

Value of "K"

① ↳ Nature of Med

② ↳ System of units in which q and r is Measured.

$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ ① Nm^2C^{-2} / ② $J \cdot m/C^2$ / ③ $kgm^3/A^2 \cdot S^4$

$\epsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$ ✓2

From Convention.

→ $F_{12} = -F_{21}$ → Equal in Magnitude.
↳ Newton's 3rd Law.

→ When dielectric is introduced, Coulomb force is decreased i.e ϵ_r is always greater than 1.

$F = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{q_1 q_2}{r^2}$ $\epsilon_r > 1$

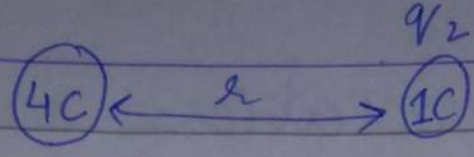
"ϵ_r times" less → $F_m = \frac{F_a}{\epsilon_r}$ $F_a > F_m$

$\epsilon_r = \frac{\epsilon}{\epsilon_0}$

for air = 1.0006 No Unit

For $_{76}Au$ it's

$F = K \frac{76e^2}{r^2}$



$F/F' = ?$

Acc to Equation $F \propto q_1 q_2$

So $F/F' = 1$ as it is a **Mutual force**.

↳ equal to product of the charges.

Electric field intensity

→ Test charge "q_0" is always unit positive.
- ↳ Used to test presence of field.
- ↳ Field exists if the test charge is present or not.

→ **More charge : More field.**

Electric field strength / Intensity

$E = F/q_0$

Direction of E is direction of Force.

$= N/C = \frac{NC^{-1}}{(1)}, \frac{Vm^{-1}}{(2)}$

$$F = K \frac{q \cdot q_0}{r^2} \hat{r}$$

$\hat{r}$ → for direction

$\hat{r}$ → Vector directed from $q \rightarrow q_0$.

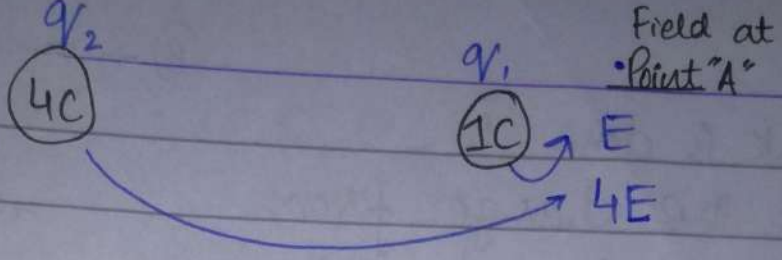
$E = F/q_0$

Put value of F given above.

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

$\vec{E} \rightarrow \vec{F} \rightarrow \hat{r}$

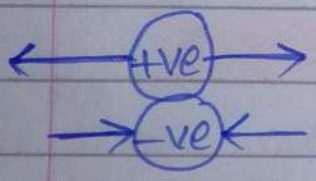
While "F" is the product of charges.



→ "E" is to be Measured with only one charge (charge of that Body) as its not mutual → other charge is considered "test charge."
i-e at point A, field due to q_1 is E.
" , field due to q_2 is 4E.

Field lines

→ path followed by Unit; Moving freely +ve charge in Electric field -



Radially Outward.
Radially inward.

∴ +ve → -ve

∴ tangent to field line at any point gives direction.

→ lines close → field strong.

→ E can have only one direction at a time.

Electric potential

Ecat 2017

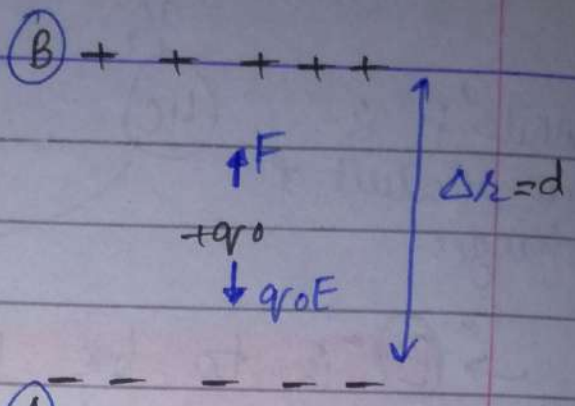
→ Moving along the line from +ve to -ve potential decreases

+ve —(+q0 q0E, Along →)→ -ve

High: +ve —(Against ←)→ -ve Low

+ve ——→ -ve

Work is done to take the charge from A → B Against the field, Keeping the charge in Equilibrium.



$W = \Delta U$

$\Delta V = \frac{\Delta U / W}{q_0}$ → potential

Work done on unit +ve charge / potential energy gap per unit charge.

$\Delta U = q_0 \Delta V = W$

$\Delta V = \frac{\Delta U}{q_0}$: $1\text{volt} = \frac{1 \text{ Joule}}{1 \text{ Coulomb}}$

$V = JC^{-1}$

$V = W/q_0$ *

When, $W = \vec{F} \cdot \vec{d}$ when for $\vec{d}$, $\vec{F}$ is constant.

$W = F d$

$W = -q_0 E d$ (-ve sign F is opposite to q_0E.)

$\Delta V = \frac{-q_0 E d}{q_0} = -Ed$

$E = -\frac{\Delta V}{d}$

* $E = -\frac{\Delta V}{\Delta r}$ → Max Value of change of potential with distance as Δr = Small.

From +ve → -ve plate → potential decreases.

-ve → direction of E along decreasing potential.

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$E = NC^{-1} = Vm^{-1}$ 2nd

$E = \frac{-\Delta V}{\Delta r}$ → Applied when for Δr → "E" is constant.

Let's say $\Delta r = d = r$ (a small distance)

$\Delta V = E \times r$

$= K \frac{q_1}{r^2} \times r$

$\Delta V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r}$ General $\Delta V \propto \frac{1}{r}$

Electric field strength of a point charge in free space/air.

$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$ $\quad r^2 = r_A r_B$

$= \frac{1}{4\pi\varepsilon_0} \frac{q}{r_A r_B}$ $\quad \Delta r = r_B - r_A$

$\Delta V = E \Delta r$

$= \frac{q}{4\pi\varepsilon_0 \times r_A r_B} r_B - r_A$

$= \frac{q}{4\pi\varepsilon_0} \left(\frac{r_B - r_A}{r_A r_B} \right)$

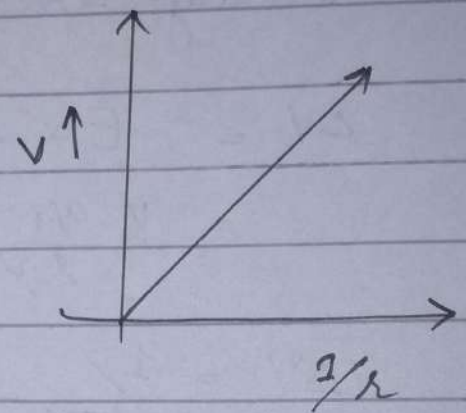
$= \frac{q}{4\pi\varepsilon_0} \left(\frac{1}{r_A} - \frac{1}{r_B} \right)$ $\quad r_B = \infty$

$$V_A = \frac{q}{4\pi\epsilon_0 r_A}$$

$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

① $E \propto 1/r^2$

② $V \propto \frac{1}{r}$



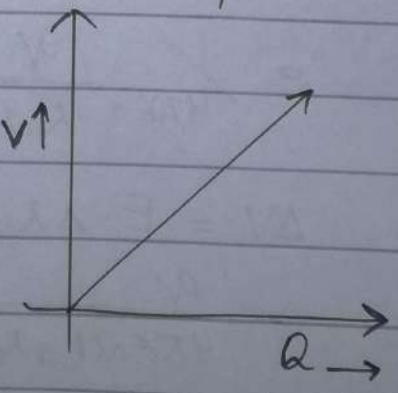
Capacitor

→ Stores charge.

→ Having 2 parallel Metal plates.

$Q \propto V$, $\boxed{Q = CV}$, $\boxed{C = \frac{Q}{V}}$

If $V = 0$
C = same
$C \neq \infty$

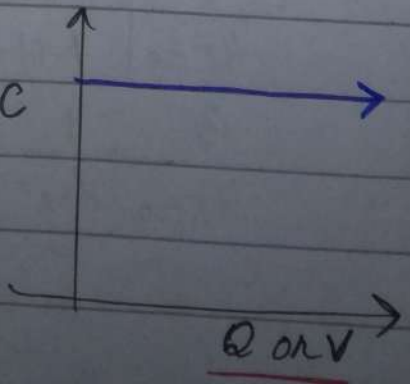


slope = $V/Q = 1/C$

capacitance depends upon

- Medium ①
- Geometry of plates ②
  - Area / distance B/w plates.

"C" is independant of Q or V.



→ Surface charge density $\sigma = \frac{Q}{A}$

→ Electric Intensity B/w charge plates $= E = \frac{\sigma}{\epsilon_0}$

$$C_{vac} = \frac{A\epsilon_0}{d} \quad *$$

"C" → A, ϵ_0, d

Medium Applied

$$C_{med} = \frac{A\epsilon_0\epsilon_r}{d} \quad *$$

$\epsilon_r > 1$, V_{med} decreases $\quad V_{vac} > V_{med}$.

$C_{med} > C_{vac}$

let's suppose a constant ← K $\quad \epsilon_r = \frac{C_{med}}{C_{vac}}$

→ "C" is then "K times" increased.

Polarization increases the capacitance because

$\sigma = Q/A$

$\sigma \downarrow$, $A \uparrow$ $C \uparrow$

$V = Ed$

$E \downarrow$, $V \downarrow$ and $d \downarrow$ so $C \uparrow$

Energy stored

$$P.E = E = \frac{1}{2} qV \quad * \quad \text{Ave. Energy.}$$

$$\text{Energy} = \frac{1}{2} CV^2 = \frac{1}{2} Q^2/C \quad *$$

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$$E = \frac{1}{2} \varepsilon_0 \varepsilon_r \times Ad E^2$$

$$\text{Energy density} = \frac{\text{Energy}}{\text{Vol}} = \frac{1}{2} \varepsilon_r \varepsilon_0 E^2$$

→ Capacitors connected in series.

Q = same

$$\frac{E_1}{E_2} = \frac{\frac{1}{2} Q^2 / C_1}{\frac{1}{2} Q^2 / C_2}$$

$$\frac{E_1}{E_2} = \frac{C_2}{C_1}$$

$$\frac{E_1}{E_2} = \frac{1}{2}, \quad \frac{C_1}{C_2} = \frac{2}{1}$$

→ Capacitors connected in parallel

V = same

$$\frac{E_1}{E_2} = \frac{\frac{1}{2} C_1 V^2}{\frac{1}{2} C_2 V^2}$$

$$\frac{E_1}{E_2} = \frac{C_1}{C_2}$$

Direct ratio.

Q ↑, C ↑

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Current Electricity

→ Conventional Current → Movement of +ve charges (+ve → -ve)

$$I = \frac{\Delta Q}{\Delta t} = CS^{-1} = \text{Ampere}$$

→ Drift Velocity $\approx 10^{-3}\ ms^{-1}$

↳ depends upon $I = nAqv_d$

∴ Heating effect of Current = $H = I^2RT$

OHM's Law → Graph of conductance is followed.

$V \propto I$ other physical parameters should be constant.

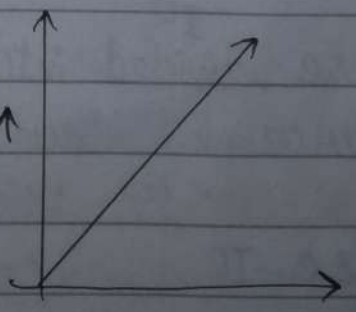
$V = IR \rightarrow$

$R = \frac{V}{I} = VA^{-1} = \Omega$

↓

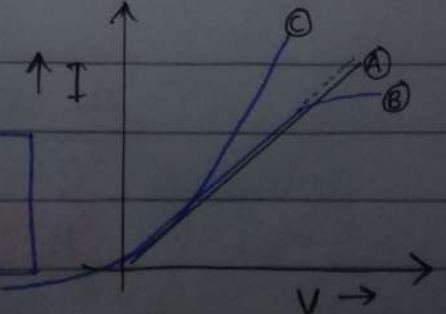
Nature (1), dimension (2), physical (3) property of conductor.

slope ← ↳ Resistance $= \frac{V}{I}$



A → straight line
↳ Conductor → ohmic

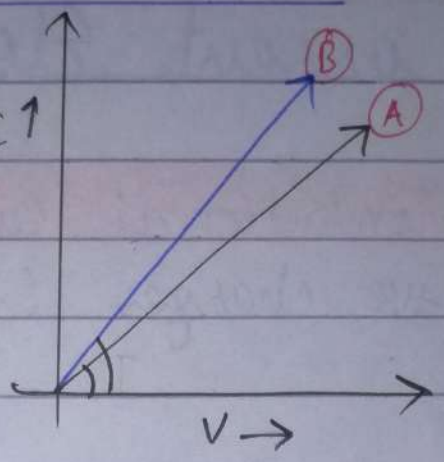
B and C → semi-conductors
↓
filament



Slope $\propto \uparrow$

$\theta = \uparrow$

conductance $\uparrow$



$\theta_B > \theta_A$

$C_B > C_A$

and $R_B < R_A$ → This Graph represents ohm's law as for the conducters.

Combination of Resistors

"n" resistors each of Resistance R = for series

is $R_e = Max = nR$

"n" resistors each of Resistance R = for parallel.

$R_e = Mini = R/n$

Case - I

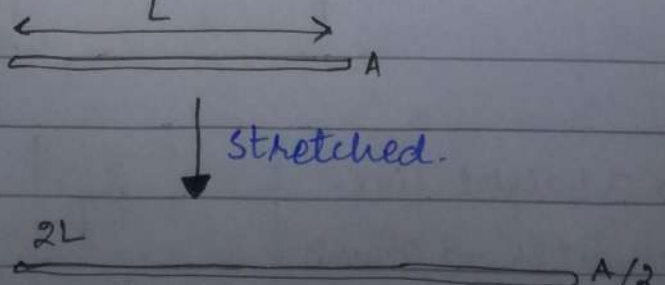
→ parallel → side by side

$R_e = R'/n^2$ ← Resistance R

I st wire, divided into n parts and 2nd joined parallel, new Eq. Resistance.

→ For each part $R' = R/n$

Case - II

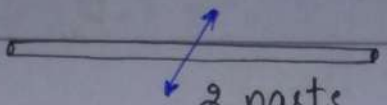


R' = 4 times

$R' \propto L^2$

By Assad Bajwa -

Case - III

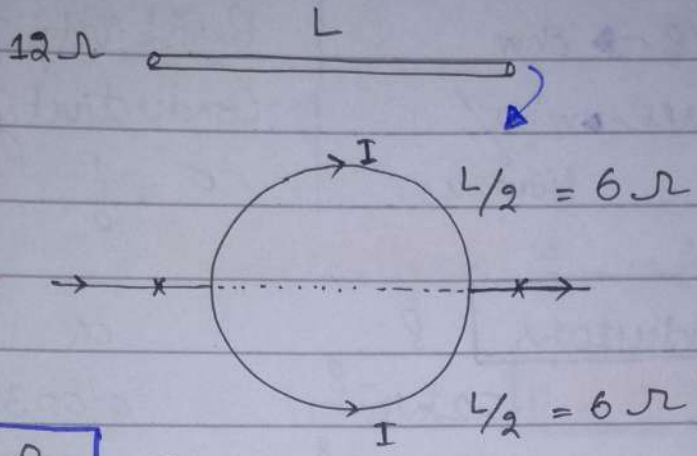


"n" parts

$R' = R/n$

$R' = R/2$ for each

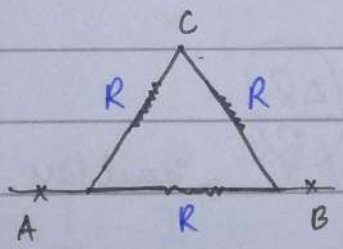
Case - IV



B/w any 2 points along diameter -

$$R_e = R/4 = \frac{12}{4} = 3$$

Case - V

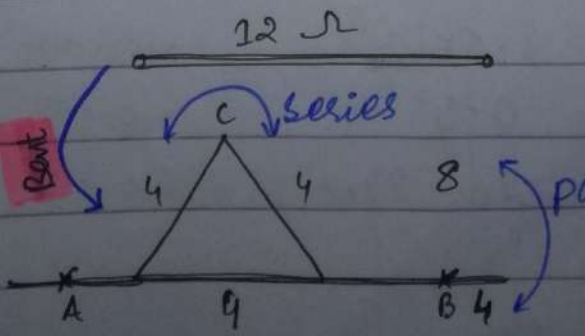


$$R_e = \frac{2R}{3} \rightarrow \frac{3-1}{3}R$$

$$R_e = \frac{n-1}{n}R$$

→ "n" resistors of each Resistance "R" taken along adj sides of the polygon -

Case - VI



$R_e = 8/3$

→ Resistivity

$$R \propto \frac{L}{A} \qquad R = \rho \frac{L}{A}$$

$$\rho = RA/L$$

Resistance → ohm	Resistivity → ohm-m
Conductance → mho / Siemen	Conductivity → $(ohm\,m)^{-1}$
	$\sigma = \frac{1}{\rho}$ Their product is equal to 1.

Best conductors	ρ	α
Silver	1.52×10^{-8}	0.00380
Copper	1.54×10^{-8}	0.00390
Gold	2.27×10^{-8}	0.00340

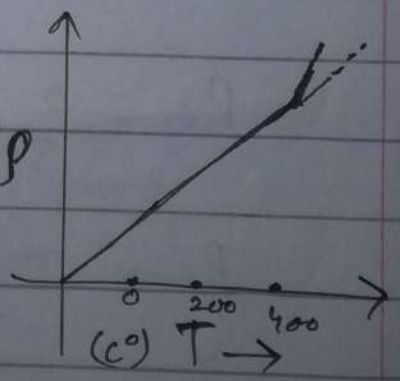
$$\alpha = \frac{R_t - R_0}{R_0 t} = \frac{\Delta R}{R \Delta t}$$ → unitless

$\alpha = K^{-1}$

$\therefore R_t \propto \Delta T$

$\therefore T \propto \rho$ ——→ For Cu

↳ Resistivity



α → +ve value → T ↑, R ↑ Conductors

α → -ve value → T ↑, R ↓ Semiconductors

	ρ	α
Carbon	3.5×10^{-5}	-0.0005
Germanium	0.5	-0.05
Silicon	20 - 2300	-0.07

Power dissipation

Work done = $\Delta W = V \times \Delta Q$

↳ energy supplied by battery.

not average energy. ←

$$\text{Power} = W/t = \frac{V \Delta Q}{t} = VI$$

↳ Generally

$P = VI$

$= I^2R$

$= V^2/R$

And Energies $E = Pt = VIt$

$= I^2Rt$

$= \frac{V^2 t}{R}$

$R \downarrow, I \uparrow, H = I^2RT$

More Brightness.

EMF : Energy supplied by Battery to unit charge by the cell.

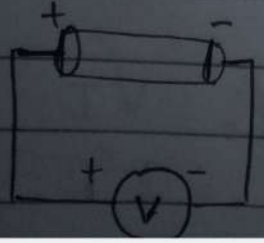
$$E = \frac{W}{\Delta Q}$$

↳ "can be equal to less or greater than terminal potential diff."

→ Max potential across terminals of Battery when I through it → Zero."

$I = \frac{V}{R}$ → Generally

$I = \frac{E}{R+r}$ → Acc to given Conditions.



→ Emf

* When a resistor is not connected
i.e $I = 0$ $\quad E = V$ emf

→ V_r : V through resistance "r"
internal resistance ↔ offered by Battery when Current is passing.

→ When a resistor of Resistance "R" is connected to a Battery of emf "E"

$E = V_R + V_r$

$E - V_r = V_R$

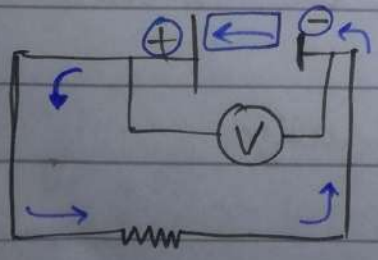
↳ Now called terminal potential → V_t

$E - V_r = V_t$

or $E - Ir = V_t$

① Battery is discharging
V_t is LESS than E
$E - Ir = V_t$

② Charging
V_t is greater than E
$V_t = E + Ir$



In circuit → +ve → −ve
In Battery → −ve → +ve

Max Power Output

Power delievered to R $= P_o = VI$
$= I^2R$

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$$P_o = \frac{E^2 R}{(R+r)^2} = \frac{E^2 R}{(R-r)^2 + 4Rr}$$ → Mini.

$\therefore P_o$ = Max

↳ When $R - r = 0$ i.e $R = R \to r$

$R = r$ and $R/r = 1$

Max power output = $E^2/4R$

$\therefore$ ~~2~~ $R \downarrow$, $I \uparrow$, $V_t \downarrow$

KIRCHHOFF'S RULES

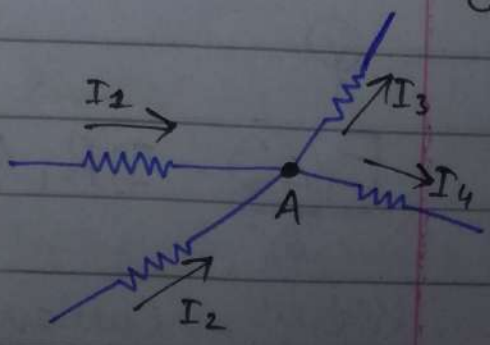
Ist rule → Current rule
→ point rule

$\Sigma I = 0$

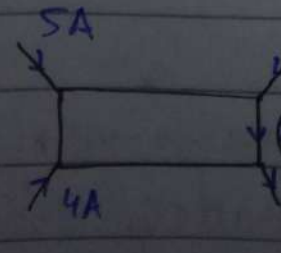
① → Sum of all currents meeting at a point is Zero.

② → Current Entering a point = Current Leaving.

$I_1 + I_2 = I_3 + I_4$



→ Law of Conservation of charges -



Given to creat Confusion

5+4+7 = 16

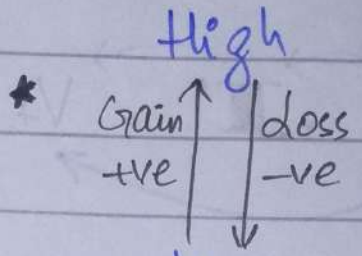
Enter = Exit

2nd Law → Voltage Rule.

↳ Algebric sum of potential changes in a closed circuit or loop is zero.

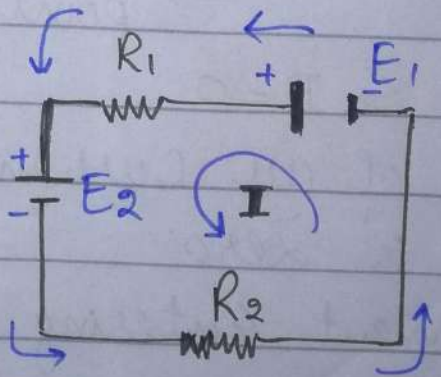
$$\Sigma \Delta V = 0$$

↳ Law of conservation of energy in Electrical terms.



Now Current High +ve → Low -ve (Loss, -ve)

In Battery: Gain (+ve)



$\therefore E_1 > E_2$

E_1 More
E_2 less

$$E_1 - IR_1 - E_2 - IR_2 = 0$$

(V)

$$E_1 \Delta Q - IR_1 \Delta Q - E_2 \Delta Q - IR_2 \Delta Q = 0$$

Highest → Current through it -ve → +ve (Gained) so positive

$-E_2 \Delta Q$ → High to low +ve → -ve → (loss) plate in Battery → so Negative

11. ElectroMegnatism

Field due to Current in a straight wire

→ Field around the straight conducter is circular and conducter is Central point.

$B \propto I$

$B \propto 1/r$ → distance not the radius -

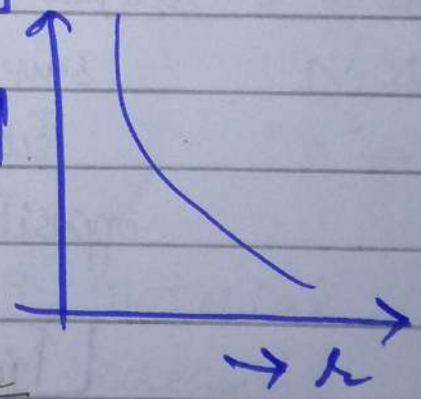
Current Reverse Field reverse

$B \propto \frac{I}{r}$

$$B = \frac{\mu_0 I}{2\pi r}$$

$\mu_0 = 4\pi \times 10^{-7}\ WbA^{-1}m^{-1}$

→ Right hand rule Direction ↓ of current and field lines



$\therefore \frac{B'}{B} = \frac{r}{r'}$

Rules:

(1) → Right hand palm rule → Direction of the Magnetic force.

(2) → Right hand rule → direction of current and the North pole.

(3) → Fleming left hand rule is also for direction of Magnetic force → for +ve charge.

Force on a current carrying conducter in Magnetic field -

$$F = KILB \boxed{\sin\theta}$$

↳ Angle B/w conductor and field -

2nd → If S.I units are followed

$\therefore \boxed{K = 1}$

$$B = \frac{F}{IL} = \boxed{NA^{-1}m^{-1}} = \boxed{Wbm^{-2}}$$

Tesla $= 10^4$ Gauss

$\theta = 90^\circ \rightarrow F_{max}$

$$\boxed{F = F_{max} \sin\theta}$$

Case -

→ Two Wires → current in same direction → Attraction

current in opposite direction → Repulsion -

Field lines

Anticlockwise
Current out of page ⊙
North pole towards us

clockwise
Current into the page ⊗
South pole towards us

By Assad Bajwa.

Current Carrying Solenoid.

↙ Ampere's law:

Magnetic field intensity

"Sum of the quantities $B \cdot \Delta L$ for all path elements into which the complete loop has been divided equals μ_0 times the total current enclosed by the loop."

↳ In case of solenoid, B/w adj turns there is no field i.e field lines.

$$B = n \mu_0 I$$

$\frac{N}{\ell} = n$ → When "ℓ" halved N also halved & "n" → constant

$B = \frac{N}{\ell} \mu_0 I$

→ Core: Ferromagnatic Material

↳ More μ_0 → B is increased.

→ "When core is inserted in a coil i.e solenoid → "B" is increased."

→ In a coil, if current is in anticlockwise direction (then left end of it) will be North pole and vice versa.

→ current loop → phantom bar Magnet.

FORCE on a Moving charge.

→ When a force is applied on a charge partical

speed = same

direction = changes i.e V= changes and Moves in circle And

$\therefore W = 0$

F is ⊥ v (1) and B (2) and plane containing v and B (3)

qvB

→ $F = -evB$ (electronic)

→ $F = +evB$ (protonic)

→ If a charge is free to Move, it will Move acc to Newton's 2nd Law of Motion

$$a = F/m = qE/m$$

$F_m = qvB$.

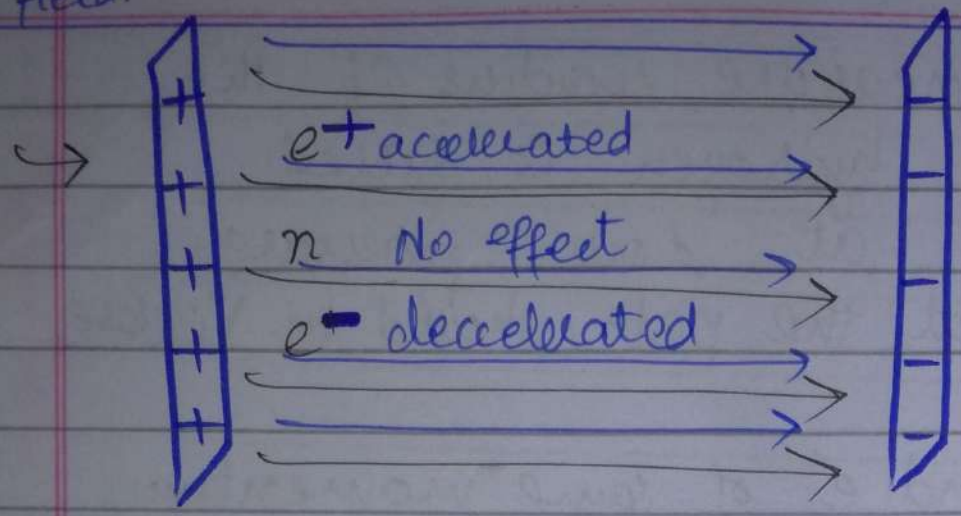
$F = F_e + F_m$

$F = qE + quB$

↳ Lorentz force.

Electric force	Magnetic force
↳ Work is done i.e in accelerating	↳ No work done. i.e simply deflecting force. → Its K.E will also be same.

Magnetic field.



$qE = F_e$

$qVB = F_m$

Both present.

→ e^+ is fired along the Magnetic field.

What will be the effect?

$\theta = 180°/0° \rightarrow F_m = 0$

$F_e = qE$, It will be accelerated.

→ If ~~electron~~ proton, It will be decelerated.

→ When a particle is deflected and starts moving in a circle,

* F_c is provided by Magnetic force.

$BeV = mv^2/r$

For a specific charge.

$\frac{e}{m} = \frac{v}{Br}$ *

$= \frac{E}{B^2 r}$ **

$= \frac{2V}{B^2 r^2}$ *

" potential with which electrons are accelerated Before entering the Magnatic field "

→ To measure radius of the ring, hydrogen is filled at low pressure so that the path should be visible.

∴ e^- and e^+ of same momentum are projected

↳ r → same for Both

$e/m = e^-$, Max

e/m = α-particle → Minimum.

12. ElectroMegnatic Induction -

Magnetic flux.

↳ Dot product of Magnetic field and Area of plane.

$$\phi_B = \vec{B} \cdot \vec{A}$$
$$= BA\cos\theta$$

"θ": Angle B/w field and Normal to the plane.

plane and field are perpendicular
Normal to plane and field are parallel $\vec{B}$ and $\vec{A}$ are parallel.
↳ Maximum Flux

Plane and field are parallel
Normal to plane and field are perpendicular
↳ Minimum Flux

$$\phi = Wb = NmA^{-1}$$

Induced emf and Current

① → Loop Moved in Magnetic field
② → field Moved near loop

↓

Flux changed / time

↓

① emf induced → ② current induced.

By Assad Bajwa -

→ Induced Current depends upon
① Speed of moving conductor
② Resistance of loop.

$I \times R =$ constant → induced emf

$I \uparrow$, $R \downarrow$

$\therefore \boxed{\phi \propto I \propto \Delta V}$

Current (induced) can be increased by
① stronger Magnetic field
② Moving loop faster
③ increasing # of turns of coil.

→ Relative Motion of loop and the Magnet produced/causes induced emf.

Magnet with North pole towards loop

① Moved towards loop
↳ Flux ↑, change in flux ↑, I → Anticlockwise.
I → anticlockwise, North pole at left, repulsion.

② Moved away from loop then Vice Versa.
↳ Flux decreasing
↳ I → clockwise.

Motional Emf

→ B and I are related.

I changed → B changed → ϕ_B is changed → emf is induced → current is induced.

→ For Motional emf

$$\mathcal{E} = \Delta V = -LvB \text{ (Magnitude)}$$

$$\mathcal{E} = -vBL\sin\theta$$

"θ" Angle B/w v and B.

→ Motional emf is a type of induced emf

Faraday's Law of ElectroMegnatic Induction.

$$\mathcal{E} = -\frac{\Delta\phi}{\Delta t}$$ for N-turns

$$\mathcal{E} = -N\frac{\Delta\phi}{\Delta t} = \underline{\text{Volt} / JC^{-1}}$$

"

→ Direction of induced emf is such that it opposes the change in flux."

ϕ = constant

$\Delta\phi = 0$

$\mathcal{E} = 0$

→ Induced Current depends upon Resistance

∴ does not depend upon the resistivity.

current loop → phantom Bar Magnet
current carrying coil → Bar Magnate.

Lenz's Law:-

① → It refers to induced current.
② → Applied to close loop or coils.
Application → from direction of induced current → direction of induced emf can be determined.

→ Current carrying coil produces a field similar to Bar Magnet.
* → Law of Conservation of Energy.
∴ "push" of the Magnet is the change that produces induced Current.

→ "Dragging force provides energy for induced currents to flow."

Induction

Mutual
↳ Henry VsA^{-1}

$$\mathcal{E}_s = -N_s \frac{\Delta \phi_s}{\Delta t}$$

$N_s \phi_s \propto I_p$

$N_s \phi_s = M I_p$

$$M = \frac{N_s \phi_s}{I_p}$$

$$\mathcal{E}_s = -M \frac{\Delta I_p}{\Delta t}$$

Self
↳ Henry VsA^{-1}

$N\phi \propto I$

$N\phi \propto$ Current in coil

$N\phi = LI$

$$L = \frac{N\phi}{I}$$

$$\mathcal{E}_L = -L \frac{\Delta I}{\Delta t}$$

TRANSFORMER → Not operated on Battery.

→ Electrical device

→ Alternating emf ⟷ Low / High Alternating emf.

Frequency remains same. ∴ Ac "f" in Pakistan 50Hz.

→ Step up/down → Voltage (Magnitude).

not a power amplifier. i-e Pinput = Poutput

→ No effect on D.C.

→ Principle : Mutual induction.

→ Electrically insulated but connected Megnatically.

Voltage ↑ Current ↓

Voltage ↓ Current ↑

→ Frequency will be same.

→ If resistance of coil is negligible, Voltage applied to primary is equal to Back emf of the Battery.

$V_p = -$ Back emf

$-N_p \frac{\Delta\phi}{\Delta t} = N_p \frac{\Delta\phi}{\Delta t}$

* → Flux is transfered in B/w the coils through [core]

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$\therefore P_i = P_o$

$V_p I_p = V_s I_s$

$$\frac{V_s}{V_p} = \frac{I_p}{I_s}$$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

→ Electrical power transfered by changing flux → transfered through core.

Principle for,

→ Transmition over long distances.

V step up I step down.

Heat loss $= I^2R$

R ↓, thick wire used, Economical? → No.

I ↓, V ↑, H ↓, Heat loss Minimum.

Power station → V → stepped up → Several* thousand Volts.

Info → Inside house → 250 → 9 Volts for Ringing Bell (1) or transistor radio (2).

Info → Transformers with several secondaries used in T.V (1) and radio receivers (2).

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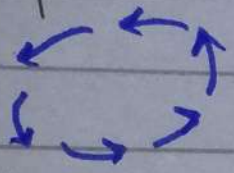
Power losses

Eddy Currents

↓

currents induced in Body of solid conducter due to changing flux.

→ Set up in the closed paths.



* → direction perp. to the flux.

Magnetic Hysteresis.

Hysteresis loss

↓

Energy expended to Magnetize and demagnetize the core Material in "A.C" → each cycle.

For Mini hysteresis loss, core of soft iron should be used.

Effect

① power loss and
② core heating.

Power loss in transformer.

Solution

Core is laminated with insulation in B/w laminations. ↓ of sheets Material with small hysteresis loop Area.

Core Material should be used with hysteresis loop Area is Minimum.
↳ Soft iron core.

→ $\text{Efficiency} = \frac{\text{Output power}}{\text{input power}} \times 100$.

Deformation in Solids

→ Results of Mechanical stress are usually expressed as i.e in terms of stress and strain.

→ $F/A = mg/A$ $\quad \frac{mgL}{AL} = gL$ *

stress = $\sigma = F/A = Nm^{-2}$ / Pascal

↳ causes change in length / Volume / shape

↓ Tensile ↓ Volume ↓ shear stress.

→ **strain** → "Measure of deformation."

$\frac{\text{change in dimension}}{\text{Original dimension}}$ $\left(\frac{l, V, \text{shape}(\Delta\theta)}{\text{Original parameter}}\right)$

→ Strain : dimensionless and Unitless

Strain

- Tensile: Increase in length
- Compressive: decrease in length.

∴ Compressional stress leads to compressibility → associated with Volume change.

→ shear stress = $\gamma = \frac{\Delta a}{a} = \tan\theta$

↳ Not Unitless → Measured in "Radians."

→ does not depend upon 'l' if A is same

→ Breaking strength → directly with Area

Elastic Constants

Modulus of Elasticity = $\frac{\text{stress}}{\text{strain}}$

→ For linear deformation it is Young's Modulus → property of material.

$$Y = \frac{F/A}{\Delta l/l}$$

Relations

Providing other factors constant in acc with state of question

→ $\Delta l \propto 1/Y$

→ $\Delta l \propto 1/A \propto \frac{1}{D^2}$ ∴ Area = πD^2

→ $\Delta l \propto L$

→ $\Delta l \propto F$

Young's Mod is inversely related with Temp.

When Vol is involved

Bulk Modulus = $K = \frac{F/A}{\Delta V/V}$

When shear stress is involved

Shear Modulus = $G = \frac{F/A}{\tan\theta}$

→ For a given stress strain graph, For a substance:

$\theta \uparrow$, $\tan\theta \uparrow$ (slope ↑)

Young's Modulus ↑

→ For small value of theta " $\frac{F}{A\theta}$ " shear Modulus is equal to -

* → If tensile stress is suddenly removed → compression
Temperature is increased.

By Assad Bajwa

→ For a given Load Extension graph, When load is same

$$\Delta l \propto 1/Y$$

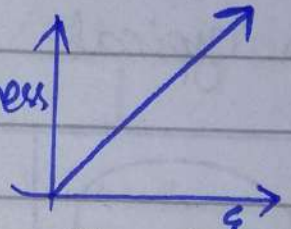
More extension for a given value of load, Y.Modulus will be Small.

$$YM = \frac{stress}{strain} = \text{slope} = \tan\theta$$

$$\therefore \frac{\tan 60}{\tan 30} = \frac{3}{1}$$

$\tan 0^\circ = 0$

$\tan 90^\circ = \infty$



→ If change in length is equal to original length, then stress and Y.M are equal.

i.e $strain = \frac{\Delta l}{l} = \frac{l}{l} = (1)$

$$Y.M = \frac{stress}{strain} = \frac{stress}{1}$$

$$Y.M = stress$$

→ According to table *

① Al → 70 (Bulk and Young's Modulus).

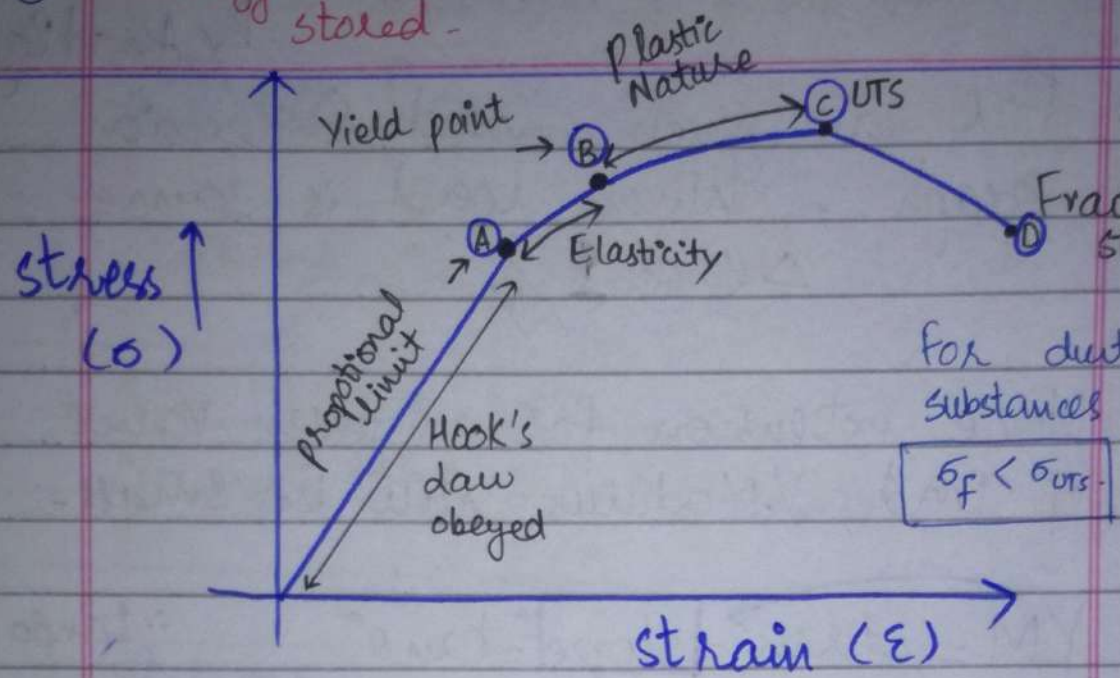
② Hg, H_2O → Have Only Bulk Modulus.

③ For Al, $\Delta l \uparrow$, $Y \downarrow$ (If same load is applied)
For Steel, $\Delta l \downarrow$, $Y \uparrow$

→ If wire is stretched Beyond Elastic limit,

① → Plastic And

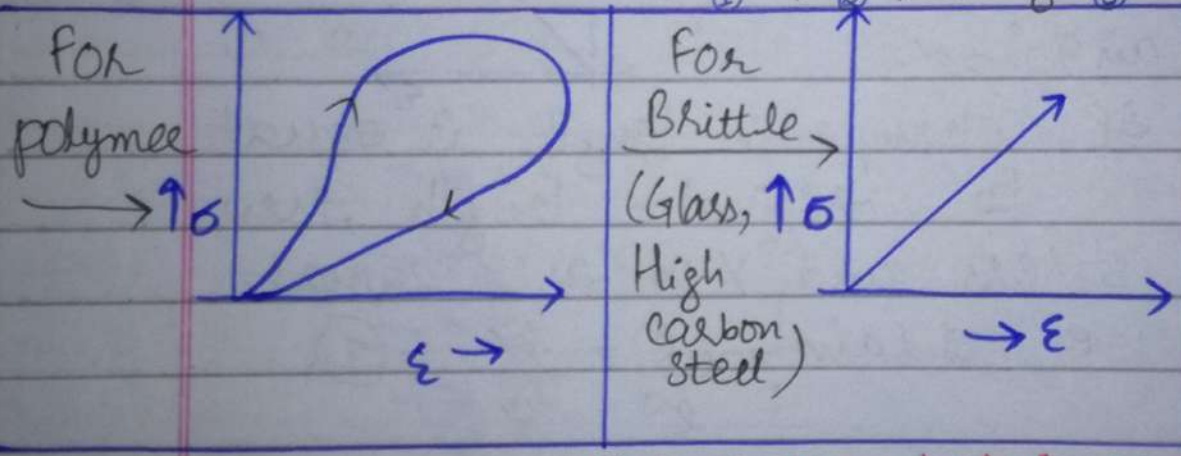
② → Energy is not stored. → Because it can't be recovered



For ductile substances

$\sigma_f < \sigma_{UTS}$.

→ for a typical ductile Material (Lead, Cu, Wrought Iron)



Energy stored in a deformed Material.

→ that energy which is recovered.

i.e in plastic deformation, "ε" is not stored.

→ Energy is stored in a deformed Material as Elastic potential energy.

When a constant force is applied, Work done is = Fd

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→ When Work is done by a Variable force

$W = \frac{1}{2} Fd$ i.e

Area Under the triangle

When Work is done on a Material, and it is deformed, Work is stored in it as energy i.e Elastic potential Energy -

$$E = \frac{1}{2} F \cdot \Delta l = U$$

$$\frac{E}{V} = \frac{1}{2} \left(\frac{F}{A} \cdot \frac{\Delta l}{l}\right) \quad \text{(Energy density)}$$

$$= \frac{1}{2} \text{ stress} \times \text{strain}$$

→ Area Under stress strain graph gives Energy density.

→ Slope of stress strain graph gives Young's Modulus -

As $Y = \frac{\text{stress}}{\text{strain}}$

$$\text{stress} = Y \text{ strain}$$

$$E.D = \frac{1}{2} Y \text{strain}^2$$

$$E.D = \frac{1}{2} \frac{\text{stress}^2}{Y}$$

$\therefore l_1 = \Delta l$

* → $W = \frac{1}{2} \left[\frac{EA \times l_1^2}{L}\right]$

L → original length.

Electronics → as per UHS Syllabus

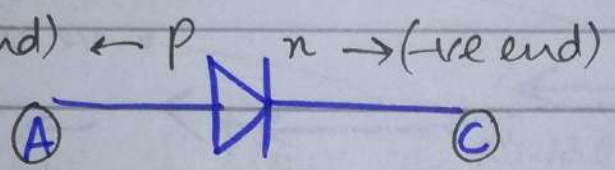
↳ Symbols are Most Important

→ Potential Barrier Value

0·7 V → Si

0·3V → Ge

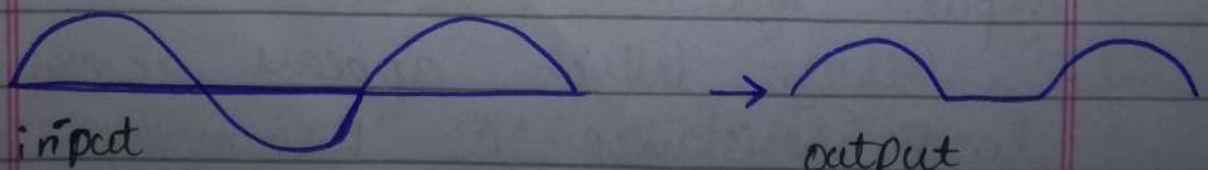
∴ → A diode Conducts Only when it is forward Biased.



Rectification :

A.C → D.C by using diodes -

- Half Wave rectification
  - ↳ Only one half of input signal is rectified. ↳ either +ve or -ve
- Full Wave Rectification



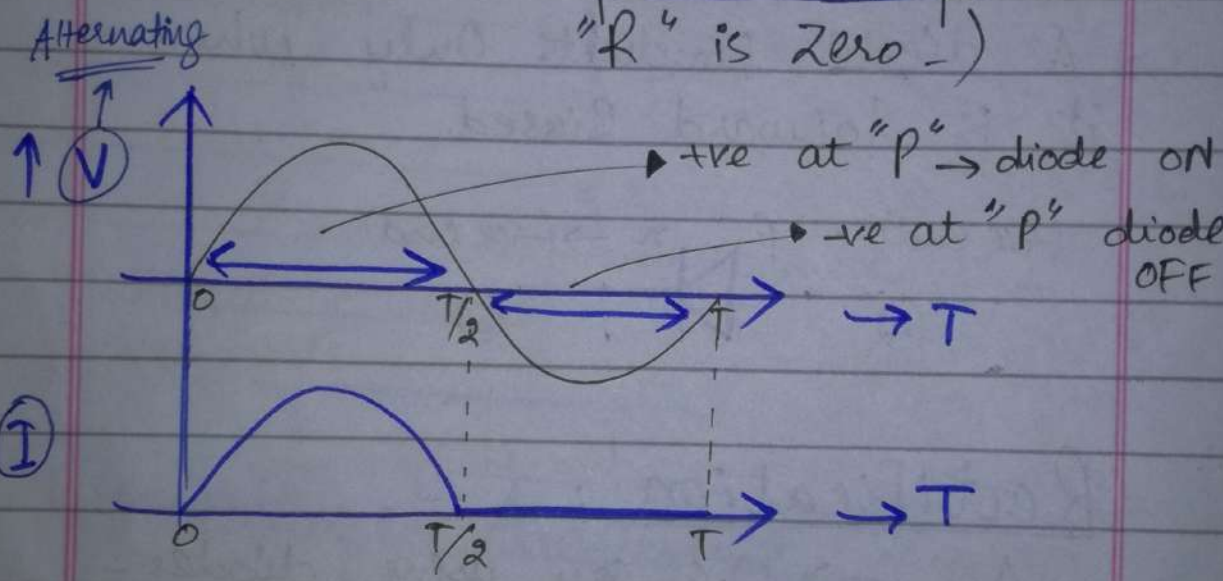
Used ↳ for charging Batteries

→ Resistance connected in series with diode ↓ load resistance.

→ to reduce ripples → filter is used.
→ Used as filters → capacitors.

→ During +ve Half, diode is forward Biased → little Resistance
→ More Current Conduction

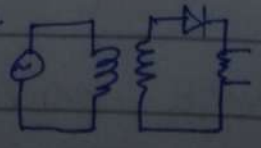
→ During -ve Half, diode is reverse biased → Max resistance
→ No current is passed. (potential drop across "R" is Zero.)



→ Current flows in pulses
→ For 1 wave i.e input signal one ripple is produced.

In Case of half wave rectification, frequency of ripples in output is equal to "f" of input A.C.

→ Voltage which appears across load resistance is known as output Voltage V_o.

Half wave Rectifier → 

Full Wave Rectification

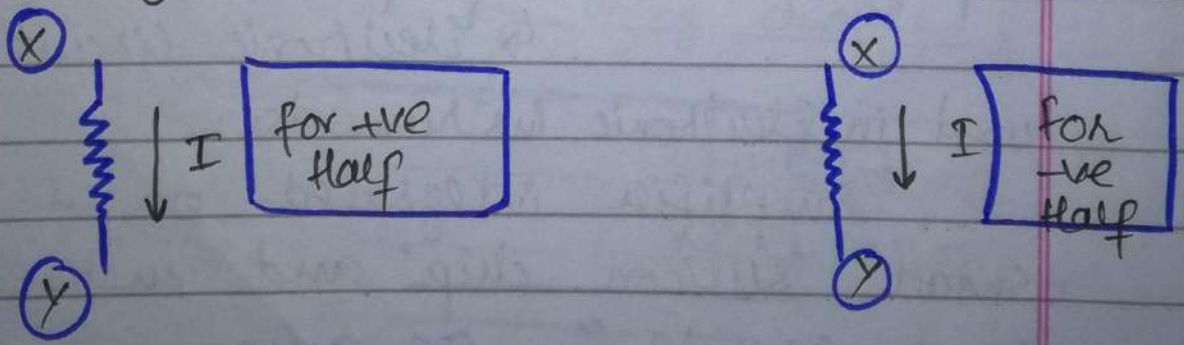
→ (4) diodes are used. i.e Bridge rectifier.

→ Both halves of wave are rectified to produce a unidirectional Current.

→ input Voltage cycle → Both halves are involved.

→ Process of rectification is essentially the same as in half wave rectification.

∴ Direction of flow of Current in load resistance is same in both halves → i.e Both halves of A.C Voltage send unidirectional Current.



→ Current is not smooth but pulsating.

→ Can be made smooth by using filter - ↳ capacitor.

→ In the case of Bridge rectification / Full wave rectification, for a single wave i.e input signal

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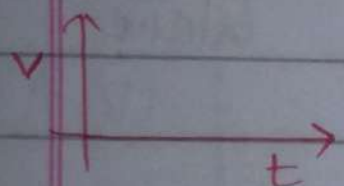
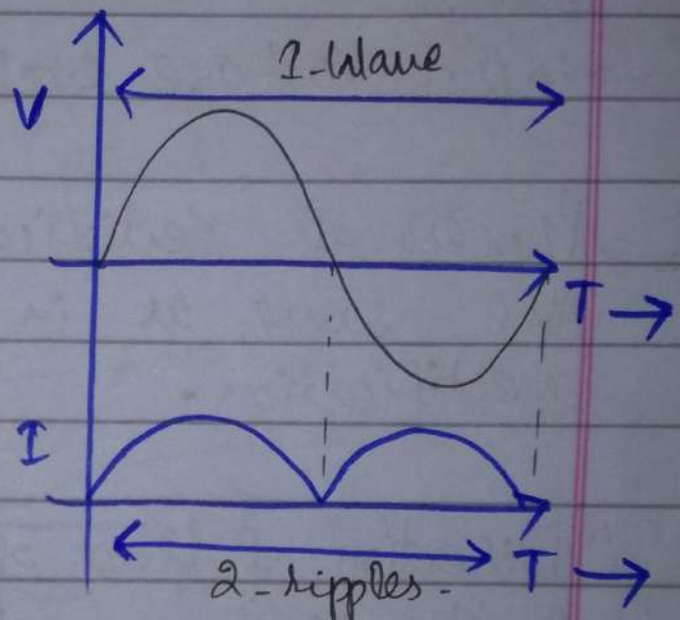
2 ripples are produced in output. So, here frequency of ripples in output is twice the frequency of input AC.

Case :-

→ "When D_1 and D_4" are off then output



No output i.e circuit is incomplete.



Operational Amplifier

↳ Electronic circuit used in Electronic instruments.

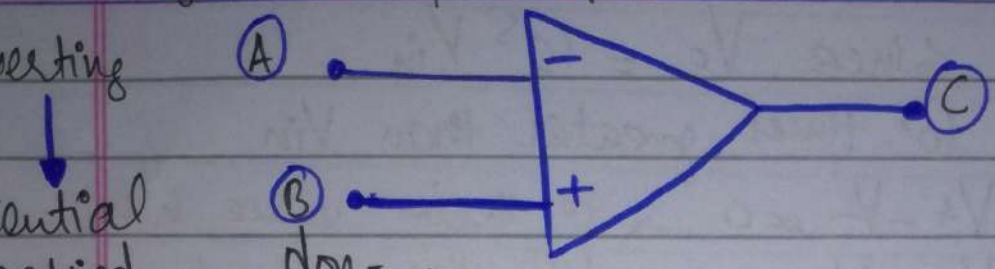
↳ Works with -ve feedback → R_2 is feedback Resistance.

"Amplifier integrated on a small "silicon chip" and enclosed in a capsule" → op-amp

∴ pins for inputs, outputs and power supply etc are projected outside the capsule.

* → Op-amp is used to perform Mathematical operations Electronically.

→ Symbol of op-amp.



potential applied

"phase change" of 180° in output signal.

↳ Potential applied (signal) input is inphase with output

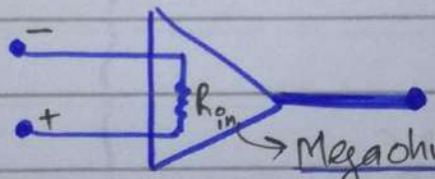
∴ "Amplification occurs in both."

Characteristics

① Output Resistance ② Input R

③ Open loop gain

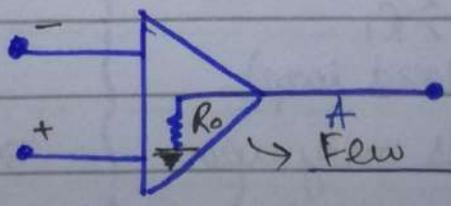
input R



↳ Megaohms i.e "MΩ"

↳ practically NO current passes

Output R

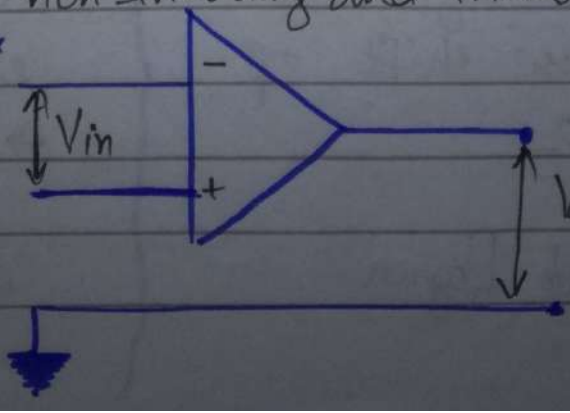


↳ Few ohms

Ratio of output voltage to voltage diff of non-inverting and inverting inputs.

$$A_{OL} = \frac{V_o}{V_+ - V_-} = \frac{V_o}{V_{in}}$$

$A_{OL} \sim 10^5$



since $V_o = 10^5 V_{in}$

V_o is 10^5 times greater than V_{in}

So $V_+ - V_- \approx 0$ → If their value has diff, then output will be either $+V_{cc}$ / $-V_{cc}$.

$V_+ \approx V_-$

OP-Amp

As Inverting

"R1" is connected to "-ve" input directly.

"+ve" terminal is grounded.

$$\frac{V_o}{V_{in}} = -R_2/R_1$$

$$G = -R_2/R_1$$

→ Gain (closed loop) depends only upon externaly connected resistances.

→ "-ve" sign shows phase shift of 180.

As Non-inverting

"-ve" terminal is grounded.

$$\frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$

$$G = 1 + R_2/R_1$$

→ Gain depends upon 2 externally connected resistances. i.e independ of external structure.

→ "+ve" sign shows input and output are in phase.

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Modern Physics.

Energy of photon

→ Energy is radiated / Absorbed in descret packets called quanta.

$$E = hf$$

→ $E \propto f$ ∴ $h = 6.63 \times 10^{-34}$ Js

→ Each Quanta responds to a single frequency.

* → Matter is consist of large # of tiny particles and is not continuous.

Photons:

① Tiny Bundles and ② are indivisible.

→ Momentum of photon related to energy is described as

* $E = pc$ → 2nd

∴ $E = hf$

$hf = pc$

$$\rightarrow p = \frac{hf}{c} = \frac{h}{\lambda}$$

→ Informations

∴ γ-rays → (1 MeV) energy Quanta.

∴ Radiowaves → 10^{-10} eV

→ Photons needed to detect a single signal in case of radiowaves → Millions i.e Wave property predominate → More wavelength

→ The Quanta are so close together in energy that radiowave is detected as continuous radiation- i.e Wave → Wave property-

Imp info.

* → Energy of photon of beam of infrared radiation of $\lambda = 1240\,nm$ is

→ $1eV = 1.6 \times 10^{-19} J$

Photoelectric Effect:

→ Due to particle Nature of light

→ Monochromatic light is shines on cathode and photoelectrons are emitted → resulting I is measured by Ammeter.

→ Current stop when light is cut off or "λ" of incident light does not corresponds to the Metal surface requirement i.e Cut off Wavelength.

∴ Max Energy of photoelectrons

→ Max Energy of photoelectrons can be measured by reversing the current of the battery.

⊛ → Current becomes zero at stopping potential V_0. $V=0$, current $\neq 0$

∴ collector plate → Anode plate.

$$\frac{1}{2} m V_{max}^2 = V_0 e$$

V_0 → stopping potential

that depends upon Speed, f, E of the photon.

photoelectrons

photons

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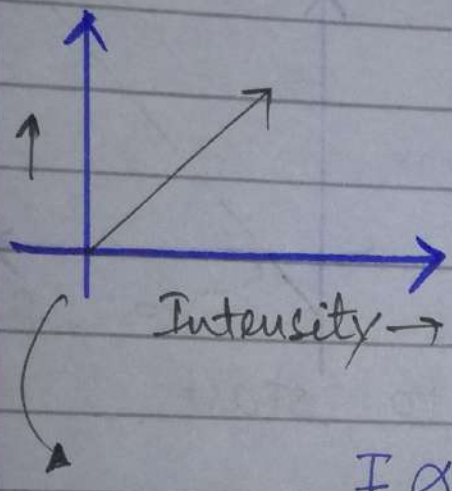
(1) Current depends upon Intensity Only.

More intensity → More Current

But V_o is same as NO change in speed, f, E of incident photons - and thus photoelectrons's speed is increased/decreased/remain same ✓



∴ V_o is independent of intensity of light.

$I \propto \frac{1}{d^2}$ Distance halved → I [4-times].

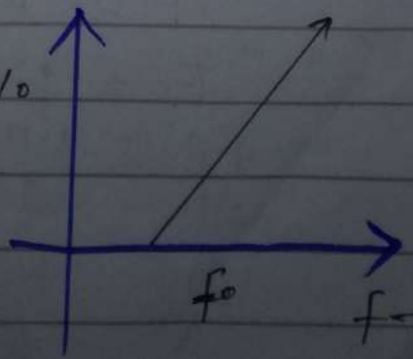
More intensity → More # of photons → More electrons Emitted → More Current.

(2) Stopping potential V_o depends upon f/E of the incident photon.

i.e photoelectrons emitted have more speed and thus harder to stop. i.e V_o ↑

→ for $f_2 > f_1$, $V_2 >$ 1st value of V_o

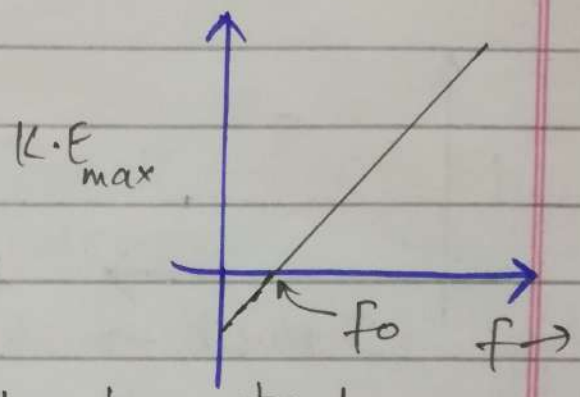
∴ Energy More → K.E More → Momentum More and thus V_o More.



Imp results of the experiment.

* ① Max Energy of photoelectrons depends upon
① Metal Surface ② "f" of incident light

② Threshold frequency Varies Metal to Metal.



→ For incident photon to start photoelectric effect

$E \geq \phi_o$ (Mini "E" to remove e^- from Metal surface.)

$f \geq f_o$ (Mini "f" to start photoelectric effect.)

* ϕ_o → Work function → depends upon Nature of Metal surface.

→ It supports photoelectric current when $f > f_o$

Explanation :-

→ It is explained on the bases of Quantum Theory.

$$E = hf$$

$$E = \phi + K.E$$

$$hf = hf_o + K.E$$

depends upon "f" of incident light

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_o} + K.E$$

→ cut off wavelength.

$$hf - \phi = 1/2\, mv^2_{max}$$

When K.E is Zero ↩

$$hf = \phi \rightarrow i.e \boxed{f = f_o}$$

Also

$$K.E = hf - \phi$$
$$= hf - hf_o$$

→ Photoelectric effect confirms the corpuscular Nature of light

Photocell :- NO Gas is used.

Anode → thin Rod

Cathode → Appropriate Metal Surface.

↳ choosed the cathode on basis of frequency of light on which cell is being operated.

* ∴ Na/K - cathode → Visible light.
* ∴ Cesium coated oxidized Silver → Infrared light.

Data-Based.

Work function for Na = 2.46eV

Cut off Wavelength is in Green → 505nm.
region of Visible spectrum

For the "Na"

↳ If light of $\lambda = 300\,nm$ is used, Max K.E is 1.68eV.

De-Broglie Wave-Particle Duality

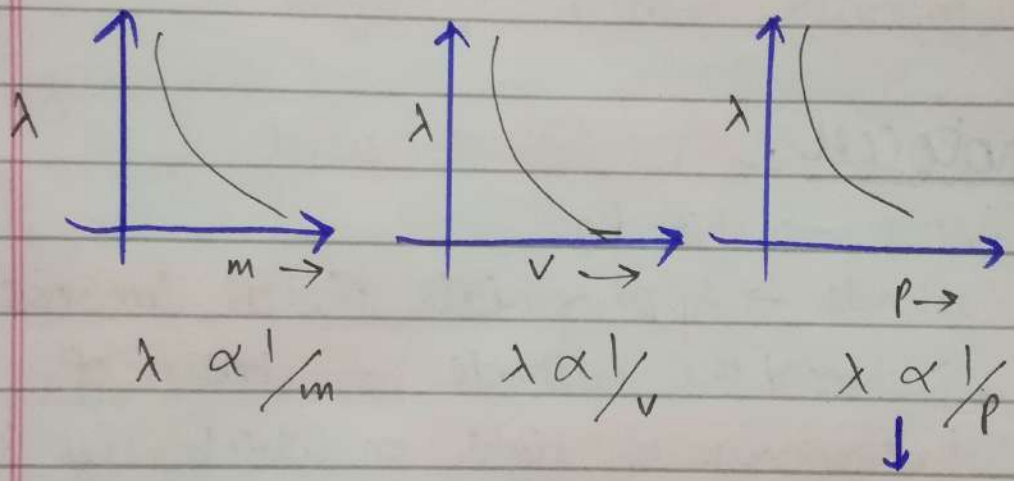
LIGHT → Propagation → Wave
LIGHT → Matter interaction → particle.

(*) Light is, in short, Most refined form of Matter

$$P = h/\lambda$$

$$\lambda = \frac{h}{P} = \frac{h}{mv}$$

"λ" is always associated with particles also-



$\lambda \propto 1/m$ $\lambda \propto 1/v$ $\lambda \propto 1/P$

* → 2 particles having same Momentum, their Wavelength would be same. → their Wavelength ratio is 1:1

For de-Broglie Wavelength,
→ Being particle is necessary for calculations.

Charged Neutral.

Data-Based.

① → Bullet of Mass 20g and V = 330 m/s
$\lambda = 1 \times 10^{-34}$ m. → Particle Nature More

② → Electron with speed $= 1 \times 10^{6}$ m/s
$\lambda = 7 \times 10^{-10}$ m (X-ray Region)
→ Wave Nature More

Davison-Germer Experiment

↳ Nickle Crystal was used.

→ Gain in K.E of electrons → potential applied.

$$\lambda = \frac{h}{\sqrt{2mVe}}$$ → For charged particle.

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$$\lambda \propto \frac{1}{\sqrt{m}} \leftarrow \lambda = \frac{h}{\sqrt{2mE}}$$ → For Neutral particle.

If $V = 54$ Volts

$$\lambda = 1.66 \times 10^{-10}\ m$$

→ Beam deflected at 65°

Bragg's Equation = $2d\sin\theta = n\lambda$

d → for Nickle $= 0.91 \times 10^{-10}\ m$

$$\lambda = 1.65 \times 10^{-10}\ m$$

2nd

→ When same potential is applied, Determine the wavelength ratio of proton and α-particle.

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha e_\alpha}{m_p e_p}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{4m \times 2e}{m \times e}} = 2\sqrt{2}$$

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Data-Based

① Particle of Mass = 5.0 mg

$V = 8.0 m/s$

$\lambda = 1.66 \times 10^{-29} m$

2p ② Electron Accelerated → V = 50 Volts

$\lambda = 1.74 \times 10^{-10} m$

i.e $V = 54 \rightarrow 1.66 \times 10^{-10} m$

$V = 50 \rightarrow 1.74 \times 10^{-10} m$

$V \downarrow \quad \lambda \uparrow$

$\lambda \propto \frac{1}{\sqrt{V}}$

Hydrogen Emission Spectrum.

Here, n is higher Energy state

p is lower Energy state.

$E_p < E_n$.

$hf = E_n - E_p$

where $E_n = -E_0/n^2$ and $E_p = -E_0/p^2$

$$hf = -E_0\left[\frac{1}{n^2} - \frac{1}{p^2}\right]$$

$$\frac{1}{\lambda} = \frac{E_0}{hc}\left[\frac{1}{p^2} - \frac{1}{n^2}\right]$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

$E_0/hc = R_H = 1.0974 \times 10^7 m^{-1}$

* → Speed of electron in first Bohr Orbit → $2.19 \times 10^6 ms^{-1}$

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Quantized Energy

$$E_n = K.E + U = \frac{1}{2}mv_n^2 + \left(\frac{-Ke^2}{r_n}\right)$$

(1) $$K.E = \frac{1}{2}mv_n^2 = \frac{Ke^2}{2r_n}$$

$$-(P.E)/2 = K.E$$

$\therefore$

(2) $$P.E = \frac{-Ke^2}{r_n} = \frac{+Ke^2}{2r_n} = (P.E/2) = +K.E$$ ★

For total Energy

$$E_n = -\frac{1}{n^2}\left[\frac{2\pi^2K^2me^4}{h^2}\right] = E_0 = \text{constant}$$

$$= 13.6eV$$

$$E_n = -E_0/n^2 \rightarrow \text{for } I^{st} \text{ Orbit}$$

$$n = 1 \quad E_n = E_0 = -13.6eV$$

(3) $$E_n = \frac{-Ke^2}{2r_n}$$

★ $$T.E = -K.E$$

→ To completely remove the electron → ionization energy and that Mini. potential is ~~ex~~ ionization potential.

$\therefore$ $n = 1$ Ground / Normal state.

$n = 2$ I^{st} excited state.

$n = 3$ 2^{nd} excited state.

→ potential for excitation : excitation pot.

→ For Removal of electron of the Hydrogen

$I.E = -E_1$

$= -13.6\ eV$

According to Energy level diagram of Hydrogen atom

For lyman = −13.6eV →

Balmer = −3.40 →

Pashen = −1.51 → eV

Bracket = −0.85 →

Pfund = −0.54 →

According to Atomic Spectrum of Hydrogen

Lyman Series = $\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$

↳ U.V. Region

$n = 2, 3, 4 \ldots$

Balmer Series = $\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$

↳ Visible Region

$n = 3, 4 \ldots$

Bracket, Pashen and Pfund are in accordance with above given calculations.

↳ infrared region.

→ From Line Spectrum of Hydrogen atom.

For Lyman Series → 91 nm → 122 nm

For Balmer → 365 nm 656 nm

Pashen Series starts from 820 nm.

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Unit # 12

Nuclear Physics.

Radioactivity

$_{92}U$ → emits radiations.

→ Polonium and radium were discovered as radioactive elements.

→ β-particles / γ-rays issue out of the Nucleus.

→ In Nuclear transmutations, 4 types of laws are obeyed.
Law of Conservation of
Mass, Energy, Charge and Momentum.

α-particle emission.

→ Mass # is decreased by 4 due to law of Conservation of Charge / Matter.

→ Charge # is decreased by 2 due to LOC of charge.

∴ Charge decreases by Magnitude 2e.

∴ Charge # is decreased by 2.

⊛ → In α-emission
2 Neutrons } are emitted.
2 Protons }

→ "Sum of Mass and Energy is remained constant."

→ α-particles.

(1) $^{226}_{88}\text{Radium} \longrightarrow {}^{222}_{86}\text{Radon Gas} + {}^{4}_{2}\text{He}$

(2) $^{238}_{92}\text{Uranium} \longrightarrow {}^{234}_{90}\text{Thorium} + {}^{4}_{2}\text{He}$

↳ Inside Nucleus

$146\,(n) \longrightarrow 144\,(n) + 2\,(n)$

$92\,(+) \longrightarrow 90\,(+) + 2\,(+)$

Uranium ⟶ Thorium + $^{4}_{2}\text{He}$

β-particles

(1) $^{218}_{84}\text{Polonium (Po)} \longrightarrow {}^{218}_{85}\text{Astatine (At)} + {}^{0}_{-1}e$

(2) $^{234}_{90}\text{Thorium} \longrightarrow {}^{234}_{91}\text{Protactinium} + {}^{0}_{-1}e$

↳ Inside Nucleus

$144\,(n) \longrightarrow 143\,(n)$

$90\,(+) \longrightarrow 91\,(+) + e^-$

Thorium (Th) ⟶ Protactinium (Pa) + $^{0}_{-1}e$

(*) → Nucleus is sometimes excited to higher state following the emission of α-particles + β-particles.

→ α and β-emission → excitation of Nucleus
→ deexcitation leads to → γ-rays production

→ X-rays has "λ" larger than γ-rays.
↳ Less Energy. ↳ More Energy

Half life :-

→ Radioactive decay process is quite random and A-symmetrical.
→ More accurate results : → larger # of atoms and thus laws of statistics is applied.

→ Half life is related to Nuclear decay.

(1) → For N=0 (complete decay) T=∞ is required.

(2) # of atoms decaying ∝ # of particles initially taken.

$$\Delta N \propto -N$$
$$\Delta N \propto \Delta t$$
$$\Delta N \propto -N\Delta t$$

$$\Delta N = -\lambda \Delta t (N)$$

More Amount initially taken : More # of atoms decaying.

$$\lambda = \frac{\Delta N / N}{\Delta t}$$

$\Delta N/N$ → Fraction of atoms decaying

λ → decay constant.

* → Decay constant Large → More Atoms decay in Δt.

→ Radioactive Element decay at a particular rate with time.

→ Graph is called decay curve and there is "Exponential decrease" in the # of atoms.

→ Atoms Undecayed = $N_0/2^n$

$\therefore n \rightarrow$ # of half lives.

→ Atoms decayed = $N_0 - N_0/2^n$

Activity $\propto$ # of atoms

$-\frac{\Delta N}{\Delta t} \propto N$

$$\lambda T_{1/2} = 0.693 \rightarrow *$$

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→ Total life of any decaying radioactive element is same i.e ∞
↳ Infinite time is required by all radioactive decaying substances to completely decay.

① U-238 → 4.5×10^9 Years Uranium 238
② Ra-226 → 1620 years Radium
③ Rn-gas → 3.8 days Radon Gas
④ U-239 → 23.5 Minutes Uranium 239.
⑤ Iodine-131 → 8 days (Artificial Radioactive)
⑥ Iodine-125 → 60 days

Nuclear fission

∴ Nuclear force > Coulomb force > Gravitational force.

→ Slow Moving ~~electrons~~ neutrons - are bombarded.
→ On Average, ③ neutrons are obtained.

→ Mass of Both products is less than Mass of Uranium.
→ Both products of Almost equal size are obtained.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + \text{Energy}$$

→ 1 Uranium Nucleus (fission) → 200 MeV

→ Per Nucleus = 200 MeV

→ per Nucleon = $\frac{200 MeV}{235}$ = 0.9 MeV per Nucleon

↑ Energy released.

→ Binding Energy per Nucleon:
Greatest for Middle Elements
less for Light / Heavy Elements.

Binding Energy per Nucleon

$^{235}_{92}U$ → 7.7 MeV

B. Energies per Nucleon

$^{141}_{56}Ba$ & $^{92}_{36}K$ → 8.5 MeV

→ So 8.5 − 7.7 → Energy at a rate of 0.9 MeV per Nucleon is given out when a uranium nucleus undergoes fission.

235 × 0.9 = 211.5 MeV

Average is considered = 200 MeV.

→ $^{235}_{92}U$ fission → Any two nuclei present in upper horizontal part of Binding energy Graph.

① → $^{132}_{50}Sn + ^{101}_{42}Mo + 3\,^{1}_{0}n$

OR

② → $^{140}_{54}Xe + ^{94}_{38}Sr + 2\,^{1}_{0}n$ ✓

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2 → Fission → easily with slow Neutrons in $^{235}_{92}U$ and Plutonium-239 → Plu

Fission chain Reaction

① NO - Neutron is utilized, 3 are absorbed / escape out
i.e Fission with initial speed? NO chain rxn

②
1 - Neutron is allowed to propagate fission - further ⇒ Controlled fission
i.e fission with initial speed? Yes.

③ All - 3 Neutrons utilized to carry out fission → Uncontrolled chain reaction → Atomic Bomb principle.

*
1 - Neutron, of all the Neutrons produced, reacts further and that Mass of Uranium → Critical Mass.

① Mass of Uranium < Critical Mass → No chain rxn (1)
② " of Uranium = Critical Mass → At initial speed (2)
③ " of Uranium > Critical Mass → Atomic Bomb principle (3)

Source of energy in atomic reactor -

Absorbers

→ Cadmium rods → Max Absorption of the Neutrons.

Nuclear Fusion :-

(*) → Binding Energy per Nucleon of fission fragments is greater than Uranium Nucleus.

8.5 MeV

B.E/Nucleon → increases upto A = 50

→ 2 Nuclei merged → A is less than 50 then energy would be given out.

(1) → 2 proton + 2 Neutrons → $_2^4He$ + (28 MeV)

→ Fusion → Mass is lost and energy is given out.

(*) More energy per Nucleon as compared to fission.

(2) → 2-Deutrons merged → $_2^4He$ + 24 MeV

(3) → $_1^2H + _1^3H \rightarrow _2^4He + _0^1n$ + 17.6 MeV

Fusion Reaction

→ To speed up the Nuclei toward each other

① Accelerator (not used at large scale)

② Temperature

10 Million °C

↳ Thermonuclear reaction

↳ available at Sun.

core temp 20 Million °C

By Asad Bajwa -

→ Fusion occurs in Hydrogen Bombs Only.

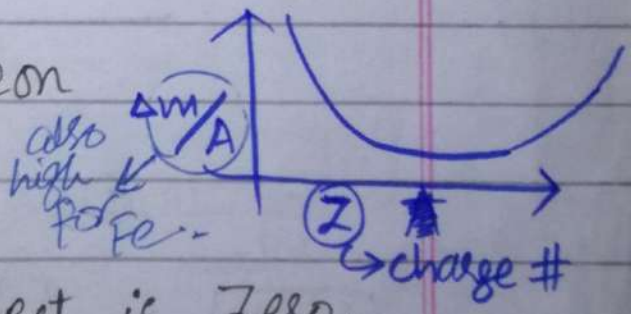
Binding Energy and Mass defect

→ Mass of Nucleus is always less than total Mass of all indivicual components.
Missing Mass → Δm → Mass defect
↓
→ converted to energy for the formation of Nucleus -

→ Bound constituents are having less energy than when they are free -

→ B.E comes from Mass that is lost during the process of formation.

Mass defect per Nucleon
↳ $\Delta m / A$.



→ For Hydrogen Mass defect is Zero.

For Helium

$\Delta m = 0.03034\ u$
$= 5.03 \times 10^{-29}\ kg$
$B.E = 4.5 \times 10^{-12}\ J$
$= 28.2\ MeV$ → for per Nucleon = 28/4 = 7 MeV

$1\ u = 1.66 \times 10^{-27}\ kg = 931\ MeV$

→ Max Value of B.E → 8.8 MeV

→ For Iron

→ A = 58

→ From all the elements, Fe is most stable.

→ B.E then decreases upto A = 238

to 7.6 MeV

∴ For the $^{2}_{1}H$ → Deutrium

Deutron Nucleus

Exp. Mass = 3.3435×10^{-27} kg

Δm = 3.9754×10^{-30} kg

And

B.E = 3.5729×10^{-13} J

= 2.23 MeV.

Proton proton cycle → 4 protons used-

Building Blocks of Matter-

Subatomic particles

① Photons ② Leptones ③ Hadrons

Elementary particles

Not Elementary

Made up of Elementary particles

Quarks

Matter

Quark Group

Leptone group

By Assad Bajwa.

Do not experience strong Nuclear Force.

Electrons, Muons, Nutrinos.

Hadrons

Experience strong Nuclear force.

Most stable ← Proton, Neutrons, Mesons.

Mass equal or greater than proton → Baryons

Mass less than protons and Neutrons → Mesons

Building Blocks of Mesons and Baryons → Quarks.

Mesons

2 quarks 1 Antiquark

Baryons

3-Quarks

→ 6-quarks are present.

Proton → 2 up and One down Quarks

Neutron → 1 up and 2 down 4-

Written By : Assad Bajwa.
MDCAT Stuff
Subject : Physics at a Glance

Short listing:

All imp diagrams, graphs, diff cases, informations, concepts etc at one place.

Unit # 01 Measurements

"Quantity is something which can be measured. If we can measure a quantity with an instrument, then it is called as physical Quantities.

→ Accessible and invariable.

→ To Measure, a standard of same Nature is selected which is called as "Unit."

① Basic / Fundamental
→ Can't be further splitted

② Derived
→ to be expressed in terms of Base.

→ M, L, T } Most Basic.

Basic frontiers → 03

③ Supplementary Units

Plane Angle → Radian = 2π rad → circle

Solid Angle → steradian = 4π steradian → sphere.

↳ Quantities.

$\therefore \frac{\text{Surface Area of sphere}}{r^2} = \frac{4\pi r^2}{r^2} = 4\pi$

$\therefore \frac{4}{3}\pi r^3$ → Volume.

→ Significant figures: Summarized

① All Known Digits

12.32 → (4)